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CHRYSLER CORPORATION

TEST REPORT

MARSH SCREW AMPHIBIAN

developed for

THE UNITED STATES NAVY
under the sponsorship of
THE ADVANCED RESEARCH PROJECT AGENCY

CONTRACT No. NObs 4558

CHRYSLER CORPORATION
DEFENSE ENGINEERING
P.O. BOX 1316, DETROIT 31, MICHIGAN

AD 636 368

CHRYSLER CORPORATION

Detroit 31, Michigan

DEFENSE ENGINEERING
P. O. BOX 1316

July 5, 1963

Letter No. 4558-18

Chief, Bureau of Ships
Code 529V
Washington 25, D. C.

Via Resident Supervisor of Shipbuilding
Kalamazoo, Michigan
1810 North Pitcher Street
Kalamazoo, Michigan

Subject: Contract NObs 4558

Gentlemen:

In accordance with contractual requirements we are enclosing herewith ten copies of the test report and approximately 1600 feet of 16 mm silent color movie film covering representative test operations of the Marsh Screw Amphibian vehicle.

Very truly yours,

CHRYSLER CORPORATION

M. J. Neumeyer
M. J. Neumeyer
Program Manager

R. E. Nichols
R. E. Nichols
Contract Administrator

REN/vfl

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FEB 1 - 1964
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FINAL TEST REPORT

ON

MARSH SCREW AMPHIBIAN

PREPARED FOR

THE UNITED STATES NAVY

UNDER THE SPONSORSHIP OF

THE ADVANCED RESEARCH PROJECT AGENCY

CONTRACT NObs 4558

Prepared by:

M. J. Neumeyer

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Project Engineer
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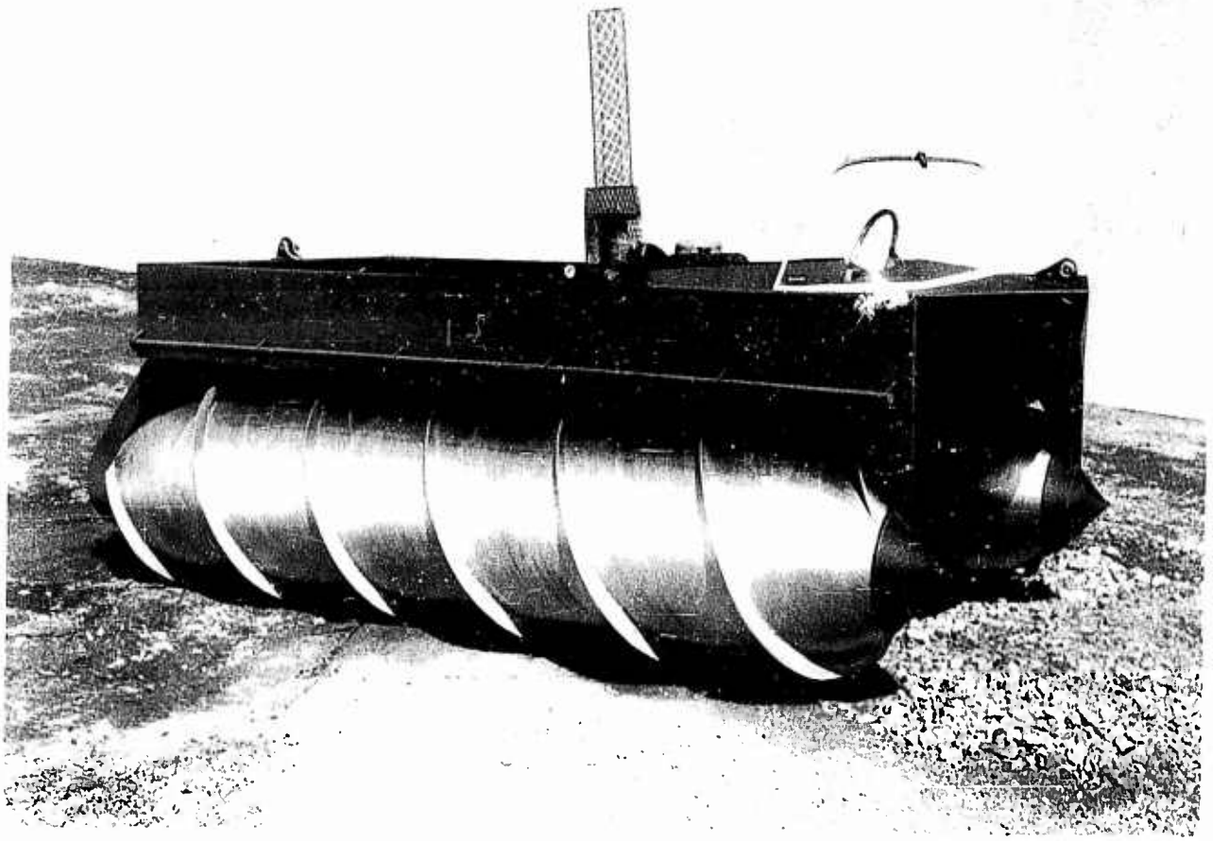
Submitted by:

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CHRYSLER CORPORATION
DEFENSE ENGINEERING
P. O. BOX 1316
DETROIT, MICHIGAN 48231



PREFACE

This report presents the results of an operational test program conducted by Chrysler Corporation on the Marsh Screw Amphibian. Modification Number Two to Contract NObs-4558, dated 14 February 1963, stated that:

> The Contractor (Chrysler) shall perform the following Test Program of the Marsh Screw Amphibian in the United States:
>
> (1) Prepare vehicle and test equipment for shipment to a test site which shall provide facilities for operation on water, sand, marsh, earth bank, and swamp;
>
> (2) Operate this vehicle for a two month period to accumulate approximately 100 hours of operation;
>
> (3) Perform maintenance and product improvement services within the limits prescribed by the Contract funding;
>
> (4) Accumulate accurate performance data in the various areas of operation.
>
> (5) Record representative operations of the vehicle on 16mm silent motion picture film.
>
> (6) Prepare and submit ten copies of a test report upon completion of testing.

The test program was conducted in three geographical locations:

(1) Michigan - water, sand, marsh, and grass covered earth;

(2) Louisiana - water, marsh, earth bank, and swamp; and

(3) Alabama - sand and surf.

The tests were accomplished during the time period from February through June, 1963 over a range of ambient temperatures from -25 degrees Fahrenheit to +90 degrees Fahrenheit. Approximately 105 hours of operation were accumulated.

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I - DESCRIPTION OF VEHICLE

1. GENERAL

The Marsh Screw Amphibian is a vehicle whose unique operational capabilities place it outside all of the normal vehicle classifications. It is not a wheeled vehicle, nor a tracked-laying vehicle, neither is it a hydro-foil nor a ground effects machine, in a word it is unique. The vehicle's name is the best possible, three-word description. Marsh is the area in which it is designed to operate and the area which it performs best. The word Screw describes the method of propulsion, which is based on the Archimedean screw, two of which are used. Amphibian is the general vehicle classification because the vehicle will run on water, marsh, and on many land conditions.

Simply stated, the Marsh Screw Amphibian floats or rides on cylindrical pontoons or rotars with rounded ends. Helixes are incorporated on the outer surfaces of these rotors, which are counter rotated to give forward thrust to the vehicle. It accomplishes its mission best over snow, mud, marsh, swampy terrain, water and sand. The general layout of this vehicle is shown in Figure I-1.

2. COMPONENT DESCRIPTION

2.1 Hull

The hull is fabricated from 6061 T6 aluminum. A sloping bow and curved sides, which

allow clearance for the rotors, and a vertical transom characterize the shape of the hull. The bow has a slight "V", and the forward top deck is topped by a curved windshield. The curved sides of the vehicle are formed 0.080-inch thick sheets, 12 feet long. The sides are riveted together along the flange seam running along the keel. The transom is a fabricated aluminum assembly, that is riveted to the sides to completely form the stern of the vehicle.

The bow consists of a bulkhead bow plate, a nose piece, a bottom plate, support brackets, and a top deck, which are riveted together and to the vehicle sides. The instrument panel (Figure I-2) and windshield are fastened to and supported by the deck, with the instrument panel serving as part of the deck structure. The three front seats are mounted on a structure that serves as a fuel tank. Four seats are also provided in back of the engine and on top of the transmission. Re-inforced, aluminum lifting-towing eyes are located at the bow and at the stern. These eyes can be used for air lift by helicopter.

A continuous grab handle, running from front to back, is provided on each side so that the vehicle may be handled, if necessary, by the troops in difficult terrain.

Front rotor supports are fabricated from aluminum and are attached to the front corners of the hull. The rotor supports are welded assemblies having a cone-shaped front section to provide low drag.

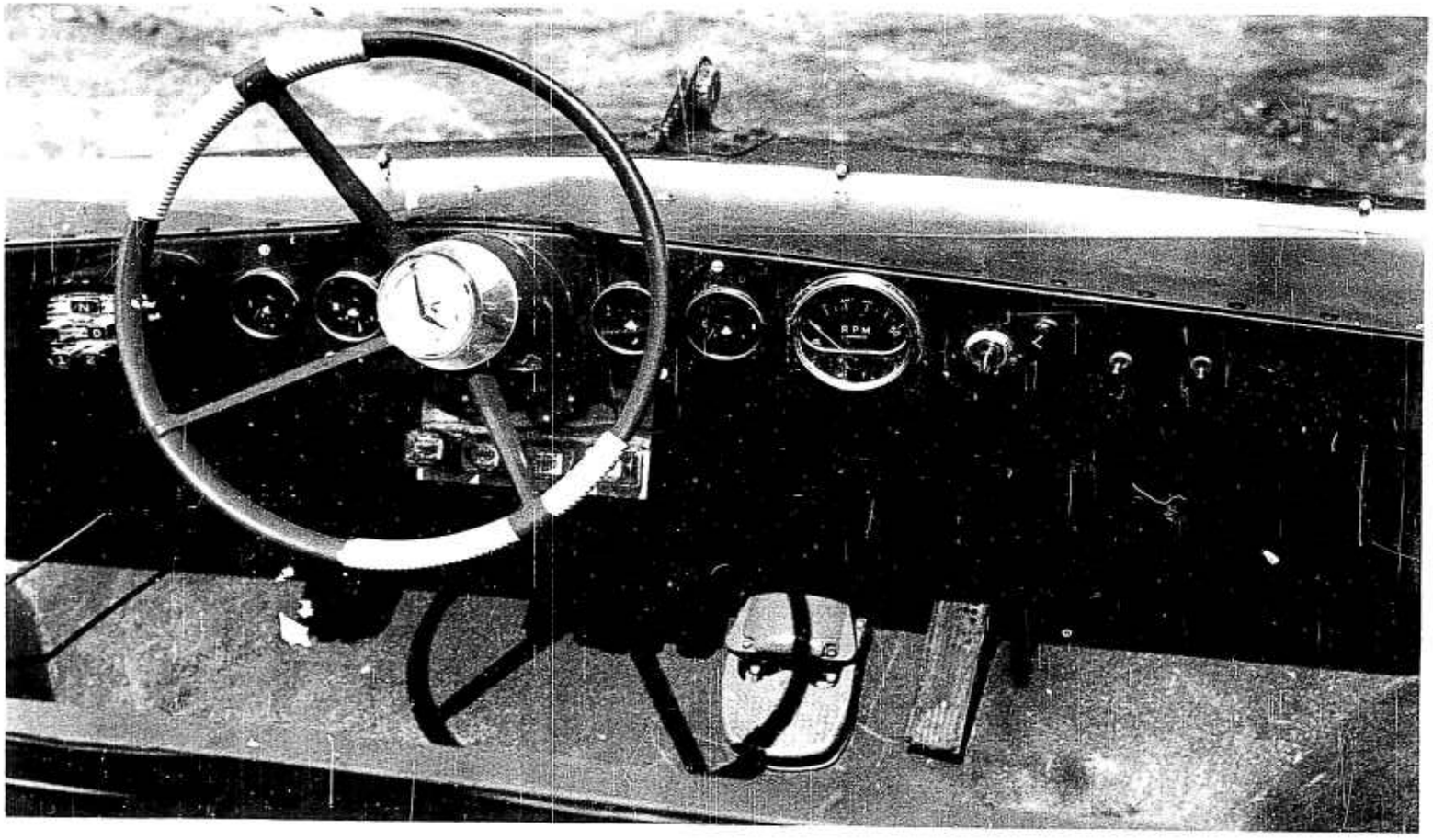


Figure I-2 Instrument Panel

2.2 Rotors

The rotors are 26-inch diameter cylinders, fabricated from 0.080-inch 6061 T6 aluminum with eliptically shaped front and rear sections, fabricated by spinning from a 1/8-inch aluminum sheet. The ends are truncated to provide a flat section for attaching the supports. The support shaft runs the entire length of the rotors at the center to provide the bearing support at the front, and the support and drive at the rear. Helical blades are welded to this structure in a continuous pattern from front to rear. There are two leads and the helix angle is approximately 32 degrees. The blades themselves are approximately 3 inches in height and 3/8-inch thickness.

Three reinforcing bulkheads support the structure along its length. Each rotor is completely filled with polyurethane foam, of approximately 1-1/2 pounds per cubic foot density, to prevent the entry of water in the event the rotor is punctured.

The right-hand rotor has a right-hand helix and the left-hand rotor has a left-hand helix. The lead of the helix is 48 inches.

2.3 Power Plant

The engine used in the Marsh Screw Amphibian is the slant 6, RG Engine. The piston displacement of this engine is 225 cubic inches. The engine has been modified to give the higher output and durability required for full-throttle, continuous performance.

The engine changes made to improve the performance include the addition of a two-barrel carburetor, a new intake manifold and a marine camshaft. Generous use of truck components increases the durability of this engine for prolonged, full-throttle

running. This engine incorporates an aluminum block that is 70 pounds lighter than its cast iron counterpart. The performance of this engine is given in the Appendix A Figure A-1.

The intake system incorporates a Chrysler 300-J air cleaner that provides minimum restriction and good filtration. It is mounted to the left front side of the engine cover. A 3-1/2 inch inside diameter hose connects the filter to the inlet of the carburetor. The two-barrel carburetor has 1-9/32 inch diameter venturiers for maximum performance. To achieve maximum performance and efficiency, the carburetor was recalibrated to match the fuel-air requirements of this engine. A velocity governor between the carburetor and the intake manifold is set to limit the engine speed at 3600 rpm. A breather connects the valve cover to a spacer between the intake manifold and the governor to reduce emission of unburned hydrocurbons. A standard exhaust manifold is connected to the engine and a special exhaust pipe sweeps down, curves approximately 180 degrees and points upwards. A straight-through truck muffler of low back pressure design is installed vertically to the exhaust pipe. The tail pipe carriers the exhaust gases above the heads of the passengers. This reduces both the sound level in the vehicle and the carbon monoxide danger to driver and crew.

The standard passenger car engine mounts are adapted to the engine and modified to mount horizontally to the brackets attached to the floor of the hull.

The fuel tank is integral with the body structure and is located under the driver's seat. The fuel lines are attached low in the center of the tank and run to a standard automotive fuel pump, through an automotive filter, and to the carburetor.

The 12-volt electrical system utilizes a 38 ampere-hour battery, starter, automotive-type distributor, and wiring. The distributor is specifically calibrated for this engine. An automotive-type alternator and starter are used in this vehicle.

The cooling system is fairly conventional, incorporating a higher output cooling fan than is normally used for this displacement engine, and a radiator of increased capacity to ensure proper cooling when operating with this higher output version of this engine. A radiator shroud is used to give good fan performance.

Cooling performance, comfort, and safety are improved by the use of an engine cover. The separation of the radiator inlet from the cover outlet limits recirculation, thus improving cooling. Passenger comfort and safety are augmented by directing the hot air up over the passenger area, to prevent accidental contact of the hot air with the passengers or hot engine components. This cover attaches to the radiator framing in front and to the passenger seat in back. An expanded metal screen is located at top rear of this cover and provides an adequate opening for free exhausting of spent cooling air.

The transmission used in this vehicle is an A-727, three-speed automatic with an A-731 torque converter, which is used in Chrysler Corporation V-8 passenger cars. Extended second gear operation will be used for high-speed water operation. The additional torque capacity of the A-727 over the A-904, which is normally used with the RG engine,

will better handle this prolonged use of second gear. An adapter plate and a crankshaft adapter are used to match the engine to this transmission.

A standard truck crankshaft that has been shot peened to provide high torque capacity and long life is used. A deep oil pan is used to provide lubrication during 60 per cent slope operation.

2.4 Steering Transmission and Final Drive

The general arrangement of the steering transmission and final drive includes a two-shaft arrangement. The input shaft is to the left and a second shaft is to the right. Power is transmitted to the second shaft through a pair of matched helical gears. Incoming power is controlled through two Bendix multiple disc electromagnetic clutches, each having a torque capacity of 1000 foot pounds. Torque is transmitted from the clutches to the input sprocket for each side. Directly behind the sprocket on the same drive is the brake for each shaft. These are Bendix electric brakes having a torque capacity of approximately 500 foot pounds. The final drive is accomplished in two stages.

(1) The first stage uses a 1/2 inch pitch Hi-Vo Morse chain and has a reduction of 3.56:1. The large sprocket of the first stage drives the smaller sprocket for the second stage.

(2) The second stage uses a 3/4-inch pitch, Hi-Vo chain and has a reduction of 1.84.1.

The over-all reduction in the chain drive is 6.55:1. The chains are of ample capacity to take the stall torque through the rotor in low gear with a modest safety factor. The steering transmission housing and final drive housing are welded fabrications. Wall thickness is held to a minimum and gusseting is used to assure adequate strength.

The lubricating system utilizes the low portion of each side of the final drive housing as dual sumps. From there, oil is picked up and brought to the lubricating pump mounted on the engine. Oil under pressure from this pump is fed through lines that spray oil on the gears coming out of mesh, on the clutch, on the brake discs, and on the chain coming out of mesh.

The needle bearings on the input shafts and on the idler shafts are pressure lubricated.

2.5 Controls

The steering wheel is connected to a series of limit switches and to a specially wound rheostat (Figure I-3). When the wheel is turned to the right, the rheostat reduces the torque capacity of the clutch to the right rotor continuously, and at 90 degrees start to apply the brake current to the right side. Continued turning to the right eliminates all right-hand clutch torque and increases the right-hand brake torque to stop the right-hand rotor. Additional controls are provided in the form of two switches that control the left and right clutch. This is useful for sideways operation over land.

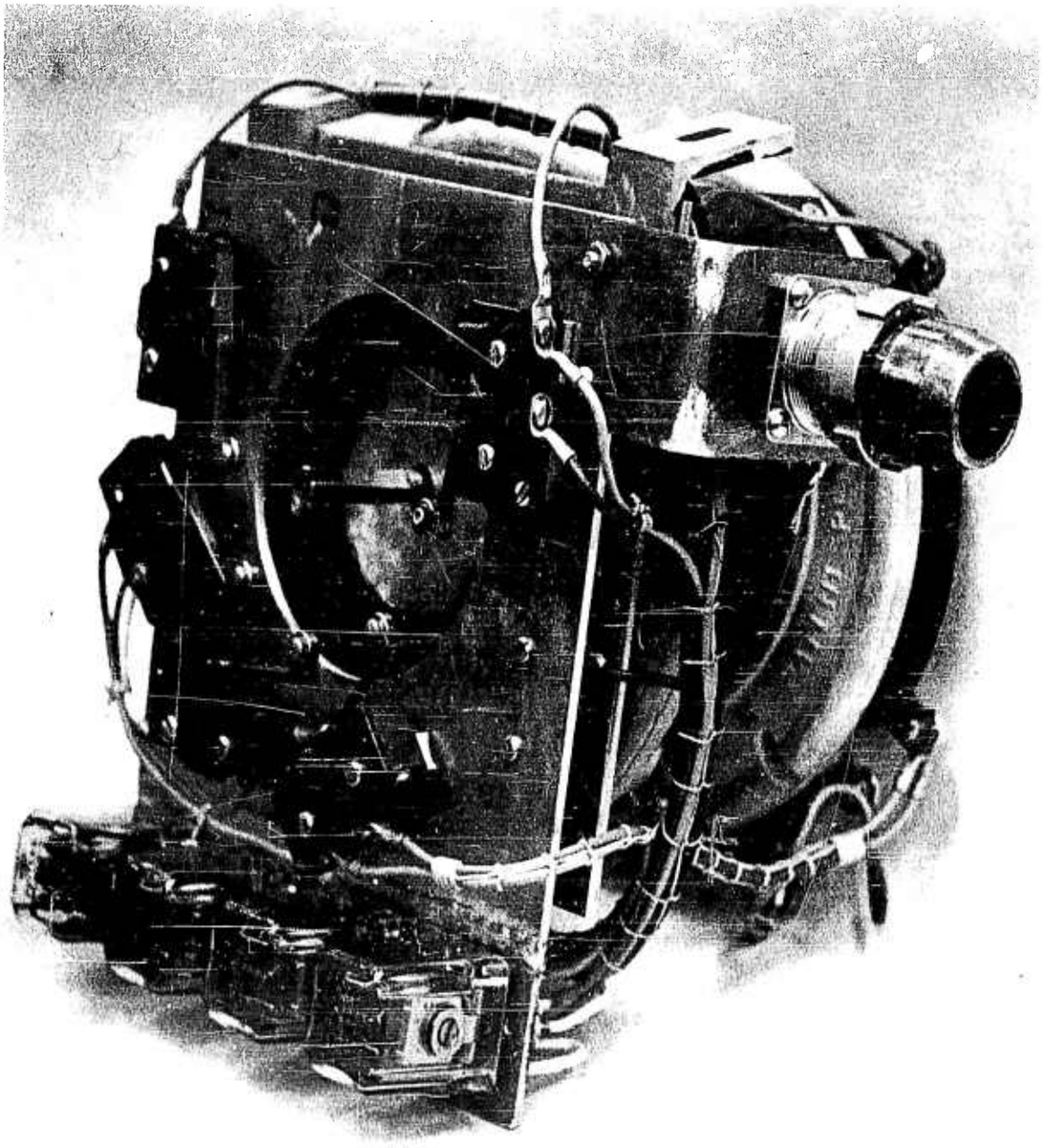
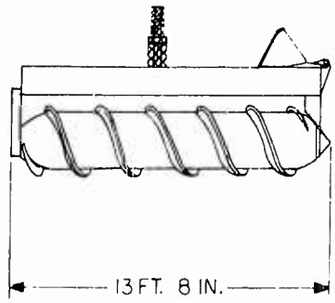


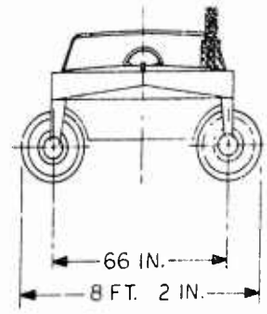
Figure I-3 Steering System Rheostat Assembly

Throttle control is conventional in that a throttle is located in the normal position on the floor board and connected through a control cable to the carburetor of the engine. A hand throttle is also provided and is mounted on the right-hand side of the instrument panel. Service braking is provided by an electric foot brake mounted to the left of the accelerator pedal on the floor, which applies both brakes, stopping both rotors. The transmission is controlled by standard passenger car push-button circuits, giving reverse, neutral, drive, second, and low ranges.

Maximum use of lightweight components and high-stress design have allowed this 1200 pound payload vehicle to have a dry weight of 2335 pounds. Over-all vehicle design has been made as simple and as non-critical to tolerance stack-up and deflection of various components as possible.

The general characteristics of the Marsh Screw Amphibian are given in Figure I-4.





GENERAL

WEIGHT (EMPTY)	2,335 LB
CREW (ONE DRIVER)	175 LB
FUEL AND OIL	175 LB
PASSENGERS (6) OR CARGO	1,050 LB
GROSS VEHICLE WEIGHT	3,735 LB
GROUND PRESSURE IS 0.9 P.S.I. AT 2-1/2 INCHES PENETRATION @ 3,735 LBS WEIGHT	
FUEL CAPACITY	45 GALS.

DIMENSIONS

LENGTH OVER-ALL	13 FT 8 IN.
WIDTH OVER-ALL	8 FT 2 IN.
HEIGHT OVER-ALL	57 IN.
ROTOR SPACING (CENTER TO CENTER)	66 IN.
ROTOR DIAMETER (OVER DRUM)	26 IN.
ROTOR DIAMETER (OVER HELIX)	32 IN.
GROUND CLEARANCE UNDER HULL	20 IN.

PERFORMANCE (MAXIMUM SPEED VEHICLE LOADED)

MUD	10 MPH 20
WATER	7-1/2 MPH 7.2
DEEP SNOW	20 MPH 25
RANGE	6 HOURS OF OPERATIONS AT FULL POWER

ENGINE

MAKE: CHRYSLER MODEL: RG SPECIAL TYPE: SPARK IGNITION, SLANT 6, WATER COOLED OHV

BORE AND STROKE	3.40 X 4.25 INCHES
DISPLACEMENT	225 CUBIC INCHES
GOVERNED SPEED	3600 RPM
NET HP	116 HP @ 3600 RPM

POWER TRAIN

TRANSMISSION: CHRYSLER TORQUEFLITE MODEL A-727, 3-SPEED TRANSMISSION WITH ELECTRIC CLUTCH/BRAKE CONTROLLED BY A STEERING WHEEL THROUGH A CHAIN DRIVEN, DOUBLE REDUCTION FINAL DRIVE, RATIO 6.55:1

ELECTRICAL SYSTEM

12 VOLT W/ALTERNATOR

MATERIALS

BODY AND ROTOR 6061 T6 ALUMINUM
ENGINE BLOCK, TRANSMISSION HOUSING, AND FINAL DRIVE HOUSING ARE ALUMINUM

Figure I-4 Vehicle Characteristics

II - BACKGROUND

The Marsh Screw Amphibian was designed and built by Chrysler Defense Engineering under Contract NObs-4558, dated 29 May 1962. The contract scope of work required that the contractor, under the cognizance of the Chief, Bureau of Ships, Code 529V, perform the following:

(1) Conduct an engineering design study including scale model tests to determine the design parameters for the full-scale prototype of the Marsh Screw Amphibian.

(2) Design, construct, and test the prototype vehicle in accordance with "Specifications for Marsh Screw Amphibian," dated 29 March 1962. The tests referred to in this paragraph were conducted by the Naval Inspector as acceptance tests and were completed prior to the accomplishment of the 100-hour test program covered by this report.

The "Specifications for Marsh Screw Amphibian" mentioned above were prepared by the Bureau of Ships, Code 529V, and provided guidance for the design of the vehicle. A review of the "Specifications" is pertinent:

Specifications for Marsh Screw Amphibian

The mission of the amphibian will be the economical transportation of six combat-equipped

men plus a driver through fresh and salt water, over beach sand, rice paddies, swamps, mud banks, earth banks, bogs, and to occasionally cross hard-surface roads.

The amphibian shall be of an austere and low-maintenance design, capable of being produced in quantity at low cost.

The amphibian shall comply with the following requirements:

(1) Speed:

(a) Land Forward - 8 mph

(b) Water Forward - 12 mph

(c) Land and Water Reverse Capability Commensurate with Propulsion System

(2) Climbing Ability:

Capable of climbing up to a 60 per cent slope in forward from a standing start and of negotiating a side slope of 30 per cent, both on a prepared earth bank.

(3) Freeboard:

The amphibian shall have sufficient freeboard to assure safe transportation of personnel when negotiating canals, rivers, choppy bay areas, and a maximum surf of two feet.

(4) Maneuverability:

Means shall be provided for steering the amphibian so that a 180-degree

turn on mud or earth can be made in a diameter of approximately two vehicle lengths and turns in water in about four vehicle lengths.

(5) Range:

The amphibian shall be capable of operating for at least four hours at full power in the water without refueling.

(6) Operating Life:

The amphibian shall exhibit low general maintenance and shall be capable of operating for periods of approximately 300 hours between major overhauls.

(7) Usability:

The amphibian shall be capable of starting and operating in ambient temperatures between 10 degrees and 115 degrees Fahrenheit.

(8) Power System:

The power system shall consist of an engine that utilizes 80 octane automotive gasoline, a power train consisting of transmission, gear boxes, clutches, chain drives and final drive as required, and a propulsion system of the worm (Archimedes Screw) rotor type for both land and water operation.

(9) Material:

The amphibian shall be unarmored and be constructed of aluminum.

The rotors shall be filled with polyurethane, foamed in place to preserve buoyancy.

(10) Lifting:

The amphibian shall be fitted with sufficient hand holds to enable the troops to manhandle it. Target weight of the vehicle is 2500 pounds, including 2/3 fuel and seven men at 175 pounds each.

The prototype vehicle was completed and began operating during the first week in January, 1963. The Acceptance Test Program was conducted in and along the north shore of Lake St. Catherine, which is approximately 30 miles east of New Orleans, Louisiana. The acceptance test was completed during the first week of February, 1963, and is covered in detail in Appendix P of this report.

Upon the completion of the Acceptance Test Program, a test plan was established by the Bureau of Ships and the contractor covering the 100-hour operational test.

III - PURPOSE AND SCOPE

After completing the acceptance tests required under the basic contract, Bureau of Ships, Code 529v, and Chrysler personnel established a test plan outline for the 100-hour operational test program. The 100-hour test program had two purposes: to accumulate operational experience in terrain environments that closely approximate those that the vehicle would encounter in South East Asia, and to accumulate accurate performance data when operating in those environments.

The test plan outline provided for operations is as follows:

Terrain Environment	Duration
Water	30 Hours
Swamp	20
Land	10
Earth Banks (Slopes)	5
Rice Paddie	20
Hard Surface (Dirt and Black Top Road)	5
Ditches and Hummocks	10
Total	100 Hours

Since appropriate conditions of terrain and weather could not be found adjacent to the Contractor's Plant in Detroit, Michigan during the months of February through April, the Marsh Screw Amphibian was transported to Chrysler's Plant facility at Michoud, Louisiana, which served as an administrative base of operations.

IV - TEST RESULTS

1. Water Performance

The vehicle was run in fresh and salt water and surf conditions up to two feet high. Details of the water performance data is found in Appendix B. Performance in two-foot surf is recorded on the film submitted with this report. Figures IV-1, IV-2, and IV-3, illustrate typical water performance of the Marsh Screw Amphibian.

Maximum water speed at Chrysler 15 Mile Road test sites was 7.56 mph loaded. This is fresh water and the average depth of the water was 5 feet and width averaged 60 feet. The depth and width limitations had some effect on reducing the maximum top speeds.

Maximum water speed on the Detroit River was 6.70 mph loaded, and 7.85 mph with driver only. This was fresh water with a depth of 27 feet and a channel width of 1000 feet. Varying currents and cross winds prevailed during these tests.

Maximum water speeds in the Michoud Canal was 7.60 mph loaded and 9.83 mph with driver only. This water was brackish and was 20 feet deep and 300 feet wide. Wind and current conditions were close to ideal.

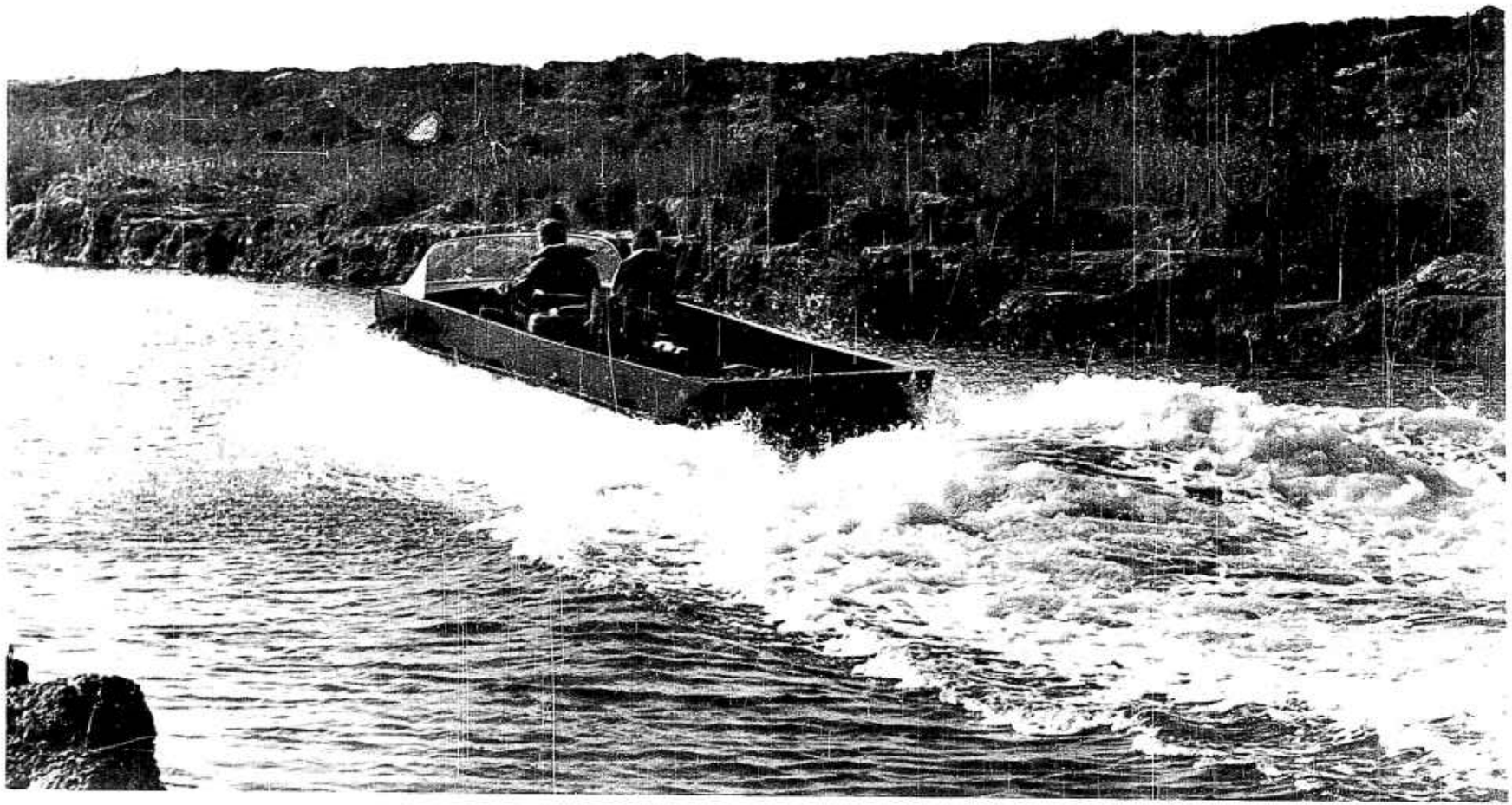


Figure IV-1 Vehicle Operation on Water



Figure IV-2 Maximum Turn Maneuver



Figure IV-3 Vehicle Operation in Reverse on Open Water

The average of these maximum speeds was 7.33 mph loaded and 8.42 mph with driver only.

Depreciating the power supply over the life of the vehicle, speeds of 7.2 mph loaded and 8.2 mph with driver only are reliable figures under average conditions for 1000 hours of vehicle life.

All attempts at increasing water speed by adding planning surface and rotor shrouds were unsuccessful. See Appendix C. The data presently available does not present a clear direction to take for increasing water speed. It is suggested that powered model tests, using not less than a 1/2 size model, be conducted to determine water speed potentials.

Tow tests of the vehicle were conducted on the Detroit River. See Appendix D. Results indicate a propulsion efficiency of 20 per cent in the 8 to 12 fps speed range. These tests were made with the rotors turning freely in the water.

Maximum static thrust was measured at 864 pounds with a loaded vehicle and 769 pounds with driver only.

2. Swamp Performance

Swamp operation was conducted on Lee's Island, New Orleans, Louisiana, and Auburn Heights, Michigan. A view of vehicle leaving a Marsh is shown in Figure IV-4.



Figure IV-4 Vehicle Leaving Marsh

Speed on a silty beach, which is between high and low tide water marks on Lee's Island, was measured at 9.88 mph over a side sloping irregular course. See Appendix E. Movie coverage of these runs is included in the film. This ground allowed a person to sink to ankle depth when trying to stand or walk. Moisture content was estimated to be 25 per cent.

Speed on a tidal mud flat on Lee's Island was calculated to be 20 mph (Appendix E). This ground allowed a person to sink to thigh depth just trying to stand on the ground (Figure IV-5). A movie sequence of this performance is included in the film. No vegetation was growing on this mud flat. Moisture content was estimated to be 30 to 50 per cent.

Operation over marsh at Auburn Heights, Michigan, was more difficult to define because of the varying density of vegetation. It can be stated that vehicle speed increased over that of water operation as the vegetation became dense enough to support the vehicle above the level assumed for water operation. A movie sequence of operation at Auburn Heights is included in the film.

At no time was it required to remove vegetation etc. that might have been expected to wind up in the rotors or rotor-rotor support areas.

The vehicle exhibited outstanding mobility in areas of mud, swamp and wet vegetation.



Figure IV-5 Tidal Mud Flat

3. Sand

Sand operation was accomplished at Damphin Island, Alabama. The vehicle first was driven over low sand dunes and hummocks for a distance of 2,000 feet to reach the beach. The vehicle was very difficult to control in the forward direction over the sand hills and hummocks. It was here discovered that negotiating this same terrain in reverse resulted in good steering control. In analyzing this reaction, it was noted that when steering while operating in reverse, the sideways frictional component of the rotor helped push the vehicle into the direction in which steering was desired. However, while moving forward, the forward end of the vehicle tends to move straight ahead, while the rear of the vehicle moves away from the direction in which steering is desired. Shifting the load to front or rear did not appreciably change this steering characteristic.

Speeds of two to three mph were attained in wet beach sand. Furrows eight to twelve inches deep were made in the wet sand. Dry sand was not available at that time.

Operation in a small sand area at Chrysler Michigan property with vehicle instrumented, measured a torque of 840 foot pounds into the final drive box, which through the chain reduction of 6.55:1, resulted in a torque of 5,500 foot pounds at the rotors. See Appendix F.

A movie sequence of operation on sand at Dauphin Island is included in the film.

4. Earth Banks and Slopes

Earth banks and slopes were run at the Michoud Canal and Chrysler 15 Mile Road property. Performance varied considerably depending upon the hardness of the slope. Along the Michoud Canal, slopes of 60 per cent and four feet high were negotiated. This operation is illustrated in Figures IV-6 and IV-7.

These slopes were composed of sand and soft dirt and left a full rotor imprint 6 to 10 inches wide. If a higher ridge or slightly overchanging plateau were encountered, the rotors would chew it away until it was brought into the general plane of the slope. At the Chrysler 15 Mile Road test site, slopes were of harder sand-clay formation, covered with grassy vegetation. Again, slopes up to 60 per cent grade and four feet high could be negotiated if they were uniform. On non-uniform slopes, the vehicle would move to one side or the other as soon as the rotors were entirely purchased on the slope. This is the same type of difficulty that was experienced with control over the sand hills at Dauphin Island.

Earth banks and slopes must be approached head-on for best results. A slanted approach would generally result in the vehicle veering off to the falling side of the slope.

There is a possibility that reversing the rotor rotation and blade leads would improve control in these areas, but with possible negative effect in water propulsion. Splash guards would then be a necessity for water and marsh operation.

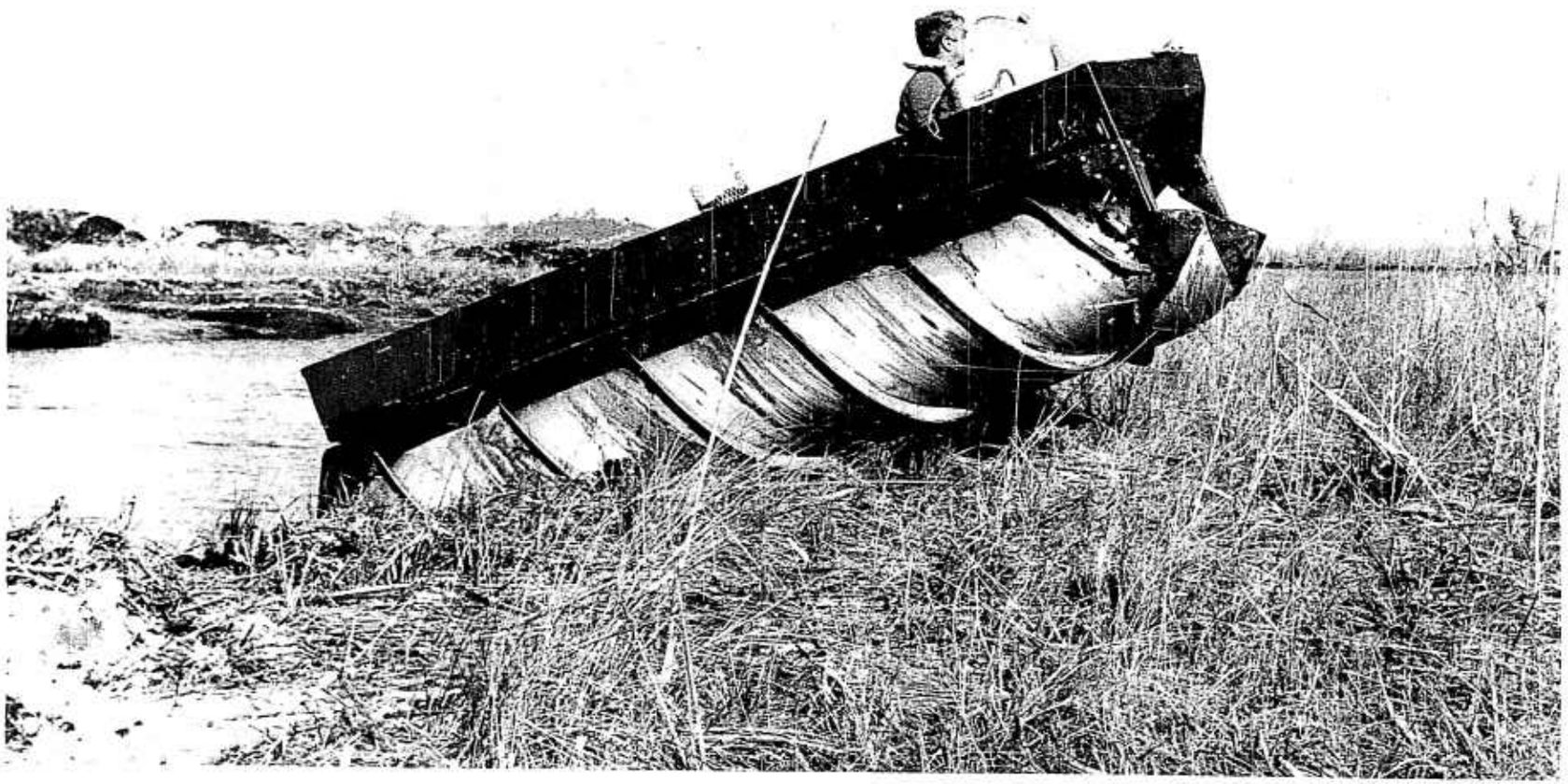


Figure IV-6 Vehicle Leaving Water

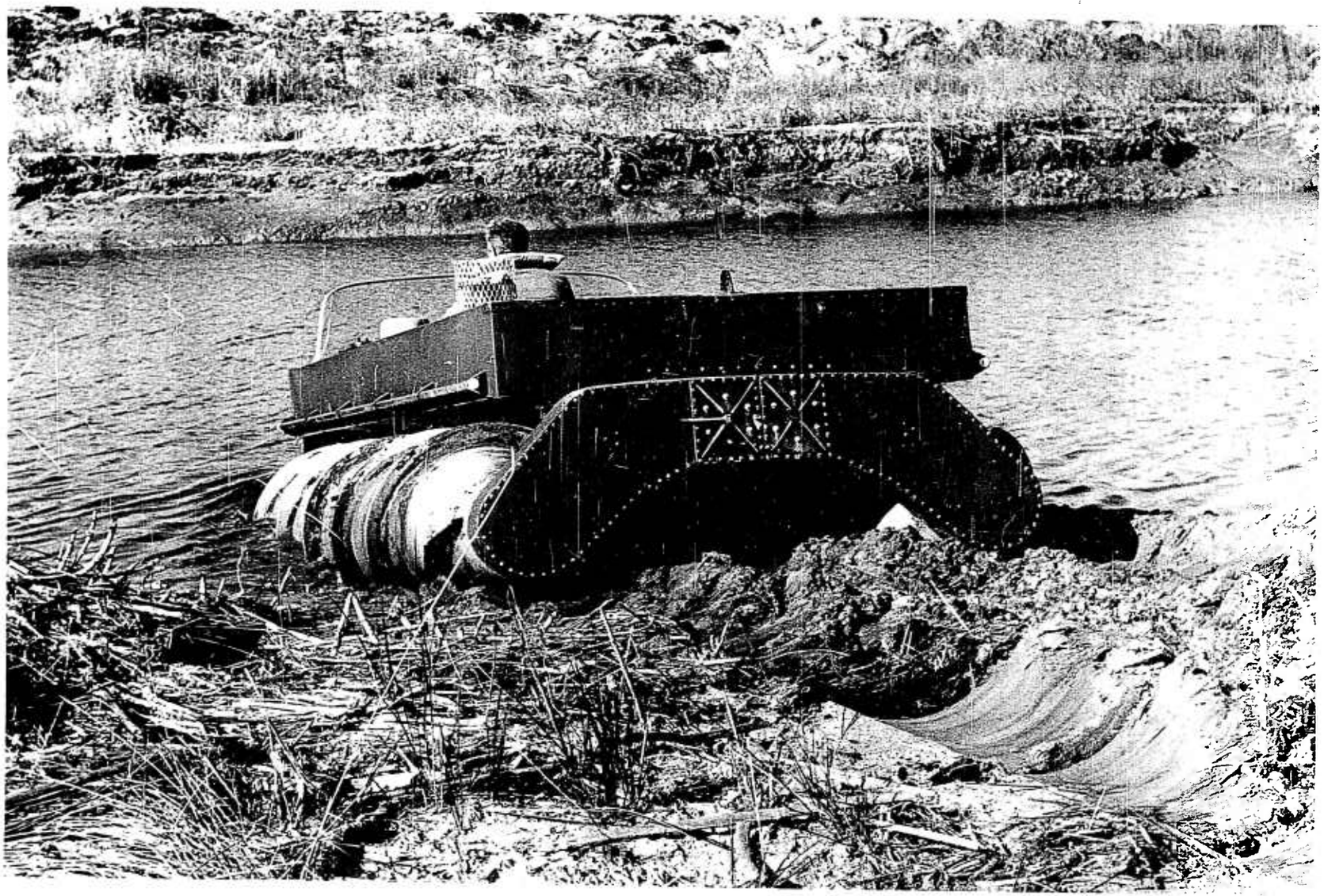


Figure IV-7 Vehicle Entering Water

A film sequence shows the difficulty and success in negotiating banks at Michoud Canal and later in the film, the difficulty encountered in negotiating the slopes at Chrysler 15 Mile Road property.

5. Rice-Paddie Grass

Areas of wild rice, Bermuda wire grass, nut grass (three cornered) and pifine grass are found on Lee's Island. Some of these areas had been burned over and the grass reduced to stubble.

Dry stubble field required operation in low gear and resulted in speeds as low as 3 mph in the forward direction. Irregularities in the terrain precluded accurate speed data for a given vegetation. The length of the island could be traveled in 10 minutes giving an average speed of 6 mph for a one mile run covering the length of the island.

No difficulty was experienced with vegetation tangling in the rotors.

6. Hard Surfaces

Hard surfaces will be defined as surfaces on which the rotor blades do not penetrate or leave a very small imprint.

On hard surfaces such as concrete and black top, the vehicle is unpredictable in directional control characteristics in forward or reverse travel. One rotor will pull opposite to the other one and depending on very slight differences in surface irregularities or friction conditions, the vehicle will move either to the right or left, or turn in circles.

Satisfactory travel over short distances can be accomplished by idling one rotor and powering the other, thus moving the vehicle sideways by a rolling action (Figure IV-8). Speeds that can be achieved during this sideway rolling operation are very high and must be tempered by operator judgement.

7. Ditches and Hummocks

Limitations on ditch crossing is the 60 per cent approach angle of the rotors. Above a 60 per cent slope approach, the rotor nose cone will begin to dig into the bank. If the surface is soft, the nose will plow through. If hard, it will stop the vehicle. Usually, the vehicle has been able to back out of a situation like this, whether uphill or downhill. When the ditch is narrow, so that the nose cone supports the vehicle in the rear, the vehicle will become immobilized. A small amount of dirt removed by shoveling will allow the vehicle to extricate itself.

Hummocks tend to move the vehicle sideways, depending upon how hard they are.

The movie film includes a water filled ditch crossing operation at Lee's Island.

8. Snow

Snow operation was performed at Chrysler Proving Grounds, Chelsea, Michigan and Chicora, Michigan.

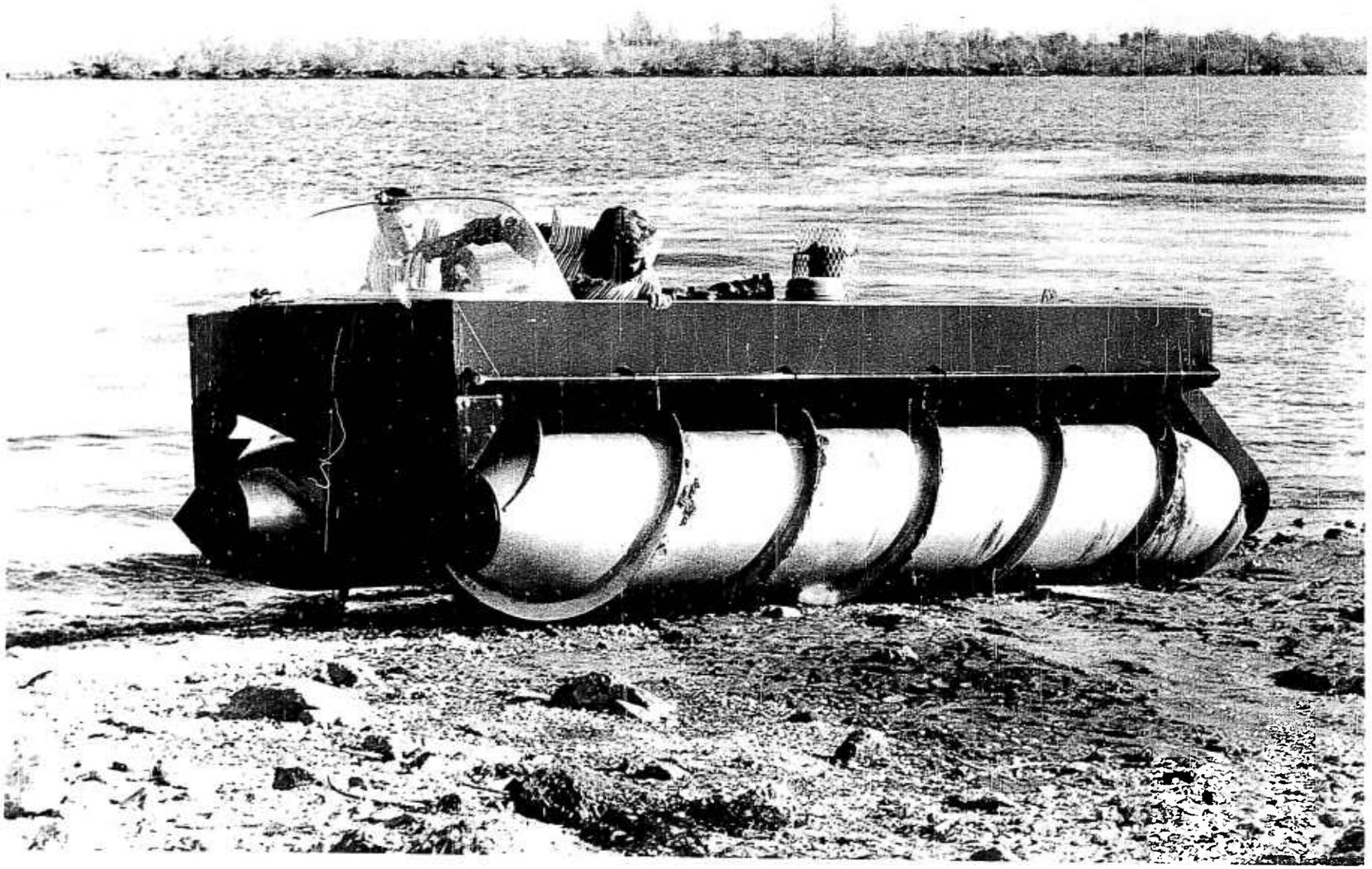


Figure IV-8 Vehicle Lateral Travel

Operation at Chelsea was over snow having a slightly crusted surface and an average depth of six inches. Vehicle speeds of 25 mph while climbing extended 10 to 20 per cent slopes were only limited by the engine governor. See Appendix G. Directional control, including sideslope operation, was considered excellent for these conditions.

Operation at Chicora was over light drifting snow (Appendix G) averaging 36 inches in depth. Temperatures ranged from 0° F to -20° F. Vehicle speeds of 25 mph were limited by the engine governor. Tracks of six inches in depths were formed by the fully loaded vehicle.

9. Fuel Consumption

Wide open throttle fuel consumption tests were run on the Detroit River. See Appendix H.

Sufficient fuel capacity is provided for six manhours of full throttle operation.

10. Durability

After the 100 hours of endurance operation had been completed, rotor wear was measured. See Appendix I.

Blade height reduction was a maximum of 1/4 inch at the front end of the rotor and 1/2 inch at the rear end of the rotors. Rotor cylinder wall thickness was reduced up to 0.010 inches at the rear of the rotors and up to 0.005 inches at the front of the rotors. A rear rotor shaft seal was the only mechanical

component that required replacing during the 100-hour endurance test program.

11. Reliability

At no time during the operation of the vehicle was it immobilized because of mechanical failure.

12. Maintainability

The vehicle consists largely of standard automotive components. All parts are easily accessable. Only one lubricant is needed to maintain the vehicle. The same oil - MIL-2-104B may be used for engine, transmission, final drive box, and front rotor bearings.

13. Vehicle Status

The vehicle improvement items (Appendix J) are scheduled for completion 8 July 1963, after which time the vehicle is available for final inspection and shipping.

V - CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

Having performed both the Acceptance Test and the 100-hour operational test programs, Chrysler believes that the Marsh Screw Amphibian is an entirely operable vehicle which meets most, but not all, of its design objectives. It is appropriate to set forth a tabulation that compares the design objectives as stated in the "Specifications" with the actual performance of the vehicle.

Speed -

(a) Land Forward - 8 mph

Land speed of the Marsh Screw Amphibian is a function of the nature of the soil over which it is traveling. Consider the following soils and vehicle speeds:

(1) Sand - 2 mph

(2) Mud having 25 per cent water content - 9.8 mph

(3) Mud having 50 per cent water content - 20 mph

It can be seen that under some conditions the vehicle exceeds the specification requirement while on sand the speed is less than 8 mph. For the vehicle mission requirement, mud, swamp, and marsh, the recorded speeds are significatnly higher than 8 mph.

Speed

(b) Water Forward 12 mph

The water speed objective of 12 mph was established at a time when there was very little experimental data to serve as a guide as to what could be achieved. Vehicle speeds in the water of 7.33 mph (loaded) and 8.42 mph (light) have been recorded in test. These speeds enable the Marsh Screw to travel faster in the water than any amphibian currently in the military inventory. On this basis, we assert that the vehicle will perform its functions satisfactorily.

Speed -

(c) Land and Water Reverse Capability

Because the transmission reverse ratio is 2.20 to 1, whereas the second speed ratio is 1.45 to 1 (in which ratio maximum water speed is attained,) speed in reverse in the water is understandably lower than forward speed. The same condition holds true for high water content mud. On sand, however, land speed is slightly higher in reverse than when moving forward; 3 mph in reverse versus 2 mph forward.

Climbing Ability

When climbing slopes, the nature of the soil determines the ease with which the vehicle can proceed as the nature of the soil had direct bearing on speed on level ground. During the acceptance test program, the vehicle demonstrated ability to climb 3-foot earth banks of 60 per cent slope.

With regard to side slope operations, the lubrication and fuel systems function properly on 30 per cent side slopes in excess of 30 per cent.

The vehicle can successfully negotiate 30 per cent side slopes on grassy surfaces. On sand, the vehicle has a component of motion laterally, downhill, due to the fact that the downhill

rotor carries a greater share of the gross vehicle weight (weight transfer) and hence has more tractive effort than the uphill rotor. On very fluid, muddy surfaces, the vehicle exhibits a natural tendency to slide downhill.

Freeboard

With one man aboard, the vehicle has a static freeboard of 39 inches at the bow and 25.5 inches at the stem. The vehicle has been operated in still water and in two foot surf at full speed with complete safety.

Maneuverability

On mud and in water, the vehicle exceeds the specification requirement for turning circle. It can turn 180 degrees in 1-1/2 vehicle lengths on mud and in four vehicle lengths at full speed in the water. At low water speeds, the vehicle can turn 180 degrees in two vehicle lengths.

On sand and hard earth, the vehicle is best turned by short back and forth maneuvers.

Range

Whereas the Specification requires four hours at full power in the water, the vehicle can actually operate for six hours at full power on its 45 gallon fuel supply.

Operating Life

The Specification requires that the vehicle operate for 300 hours between major overhauls. All vehicle components were selected to give far greater than 300 hour service and during the total of 122 hours of operation accumulated at the time of this report, no disabling malfunctions have occurred.

Usability

The Specification requires that the vehicle be capable of starting and operating in ambient temperatures between ∱ 10 degrees and ∱ 115 degrees Fahrenheit. The vehicle has given completely satisfactory starting and operating performance under all conditions of weather and temperatures which have ranged from -25 degrees to ∱ 90 degrees Fahrenheit.

Power System

The vehicle meets all the mandatory requirements as stated in the Specification.

Material

The material used in the vehicle fully conforms to the specification. The hull is a riveted assembly made from 6061-T6 aluminum. The rotors are polyurethane filled and are of welded 6061-T6 aluminum construction.

Lifting

The original intent was to make the vehicle light enough so that it could be man-handled on the ground. A target weight of 2500 pounds (gross) was set up in the Specifications.

The prototype vehicle weighs 3735 pounds with seven men and 2/3 fuel load. In the test program we have learned that while the vehicle cannot be lifted by seven men, it can be rolled laterally by one man. It can also be driven sideways under its own power. While this mode of operation was not envisioned at the outset of the program, it has proven to be a most effective means of traversing hard survaces. The vehicle is fitted with lifting eyes so that it may be helicopter lifted over long distances or over terrain which it cannot cross (mountains for example).

While the actual vehicle weight exceeds the target weight and hence the vehicle cannot be man handled (lifted,) it can be rolled or air lifted and possesses a degree of mobility which no other military amphibian can exhibit. We conclude, therefore, that its weight does not militate against its usefullness.

2. RECOMMENDATIONS

Chrysler offers two recommendations with regard to the immediate future:

(1) The Marsh Screw Amphibian should be subjected to field use in the environment for which it was designed in order to collect data which may serve as a guide for a product improvement program.

(2) An analytical and scale model experimental program should be undertaken to develop accurate design data on the Archimedes Screw as a means of propulsion. A sound beginning was made during the engineering design study phase of the Marsh Screw program. Much work remains to be done, and if undertaken now, can be completed while the prototype vehicle is being used to gather full scale operational data.

APPENDIX A - ENGINE AND TRANSMISSION PERFORMANCE

The following set of tables and figures describe engine performance, engine and converter combined performance, and engine and transmission (with converter) performance.

Figure A-1 gives engine net horsepower and torque over the speed range from 1200 rpm to 4000 rpm. The engine is described in Paragraph 2.3. Full accessories were used including fan, muffler, and air cleaner, but did not include lubrication pump. Losses for pump would be about 1 1/2 hp at full 4000 rpm.

Table A-1 shows engine and converter matching data. Characteristics of both units are used to calculate output torque and speed. This is done over the entire speed ratio from stall (zero output speed) to 4000 engine rpm.

Figure A-2 is a plot of the results of the converter output as determined in Table A-2. It shows net output torque versus output speed in rpm over the speed range.

Data Sheet A-2 shows transmission output torque and speed in all three forward speeds. Efficiency used for this is 94 per cent in first gear, 96 per cent in second gear, and 98 per cent in high gear.

Figure A-3 is a plot of the transmission output based upon the values determined in Table

A-2. Output torque and speed are given for each speed throughout the speed range up to 3600 engine rpm.

Figure A-4 shows the relationship between engine rpm and converter output rpm for the speed range up to 4000 engine rpm. From this curve, it is possible to determine engine speed from output speed and output speed from engine rpm.

Figure A-5 is derived from Figures A-3 and A-4 and from Table A-2. It gives transmission output horsepower in all three forward speeds and gives engine rpm throughout the speed range up to 4000 engine rpm.

TABLE A-1 - CONVERTER, ENGINE MATCH AND OUTPUT

SPEED RATIO	TORQUE RATIO	ENGINE RPM	ENGINE TORQUE	OUTPUT RPM	OUTPUT TORQUE
0	2.13	1420	186	0	396
.3	1.77	1470	189	441	334
.5	1.52	1540	191	770	290
.7	1.25	1660	193	1160	241
.85	1.05	1860	193	1580	203
.9	.99	2000	191	1800	189
.93		2160	190	2010	188
.95		2370	189	2250	187
.96		2650	187	2540	185
.97		3200	183	3100	181
.97		3600	171	3490	169
.97		4000	155	3880	153

TABLE A-2 - TRANSMISSION OUTPUT

1ST			2ND			3RD		
RPM	HP	T	RPM	HP	T	RPM	HP	T
0	0	912	0	0	551	0	0	388
180	26.4	769	304	27.0	465	441	27.5	327
314	39.1	667	531	40.8	403	770	41.6	284
474	50.1	555	800	51.1	335	1160	52.1	236
645	57.5	468	1090	58.8	283	1580	60.0	199
735	60.9	435	1240	62.1	263	1800	63.4	185
820	67.5	432	1390	69.1	261	2010	70.5	184
918	75.2	430	1550	76.8	260	2250	78.5	183
1040	84.3	425	1750	85.7	257	2540	87.6	181
1265	100.0	416	2160	103.5	251	3100	104.5	177
1425	106.0	390	2410	108.0	236	3490	110.5	166
1585	106.0	351	2680	109.0	213	3880	111.0	150

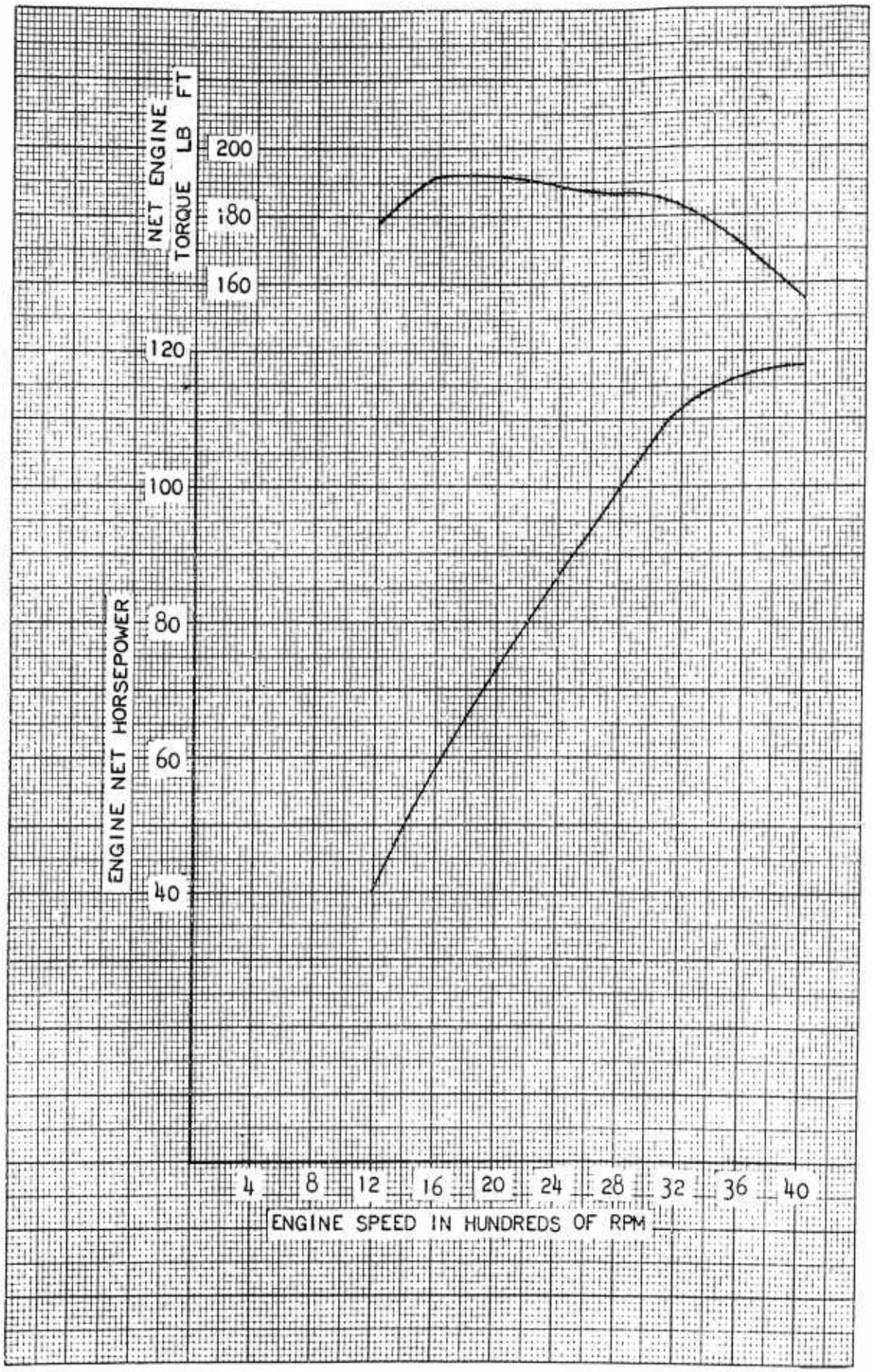


Figure A-1 Net Engine Torque and Horsepower

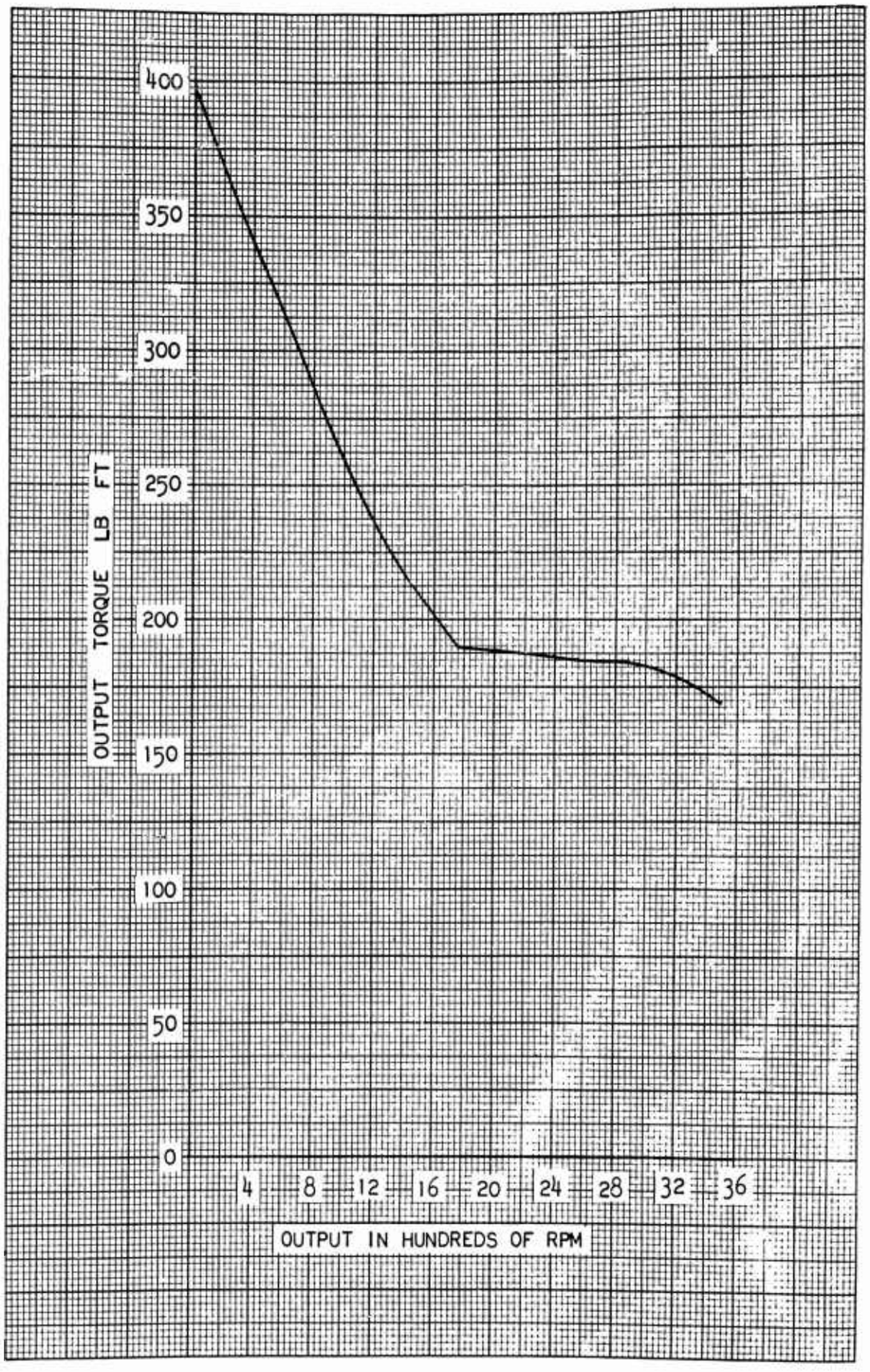


Figure A-2 Torque Converter Output

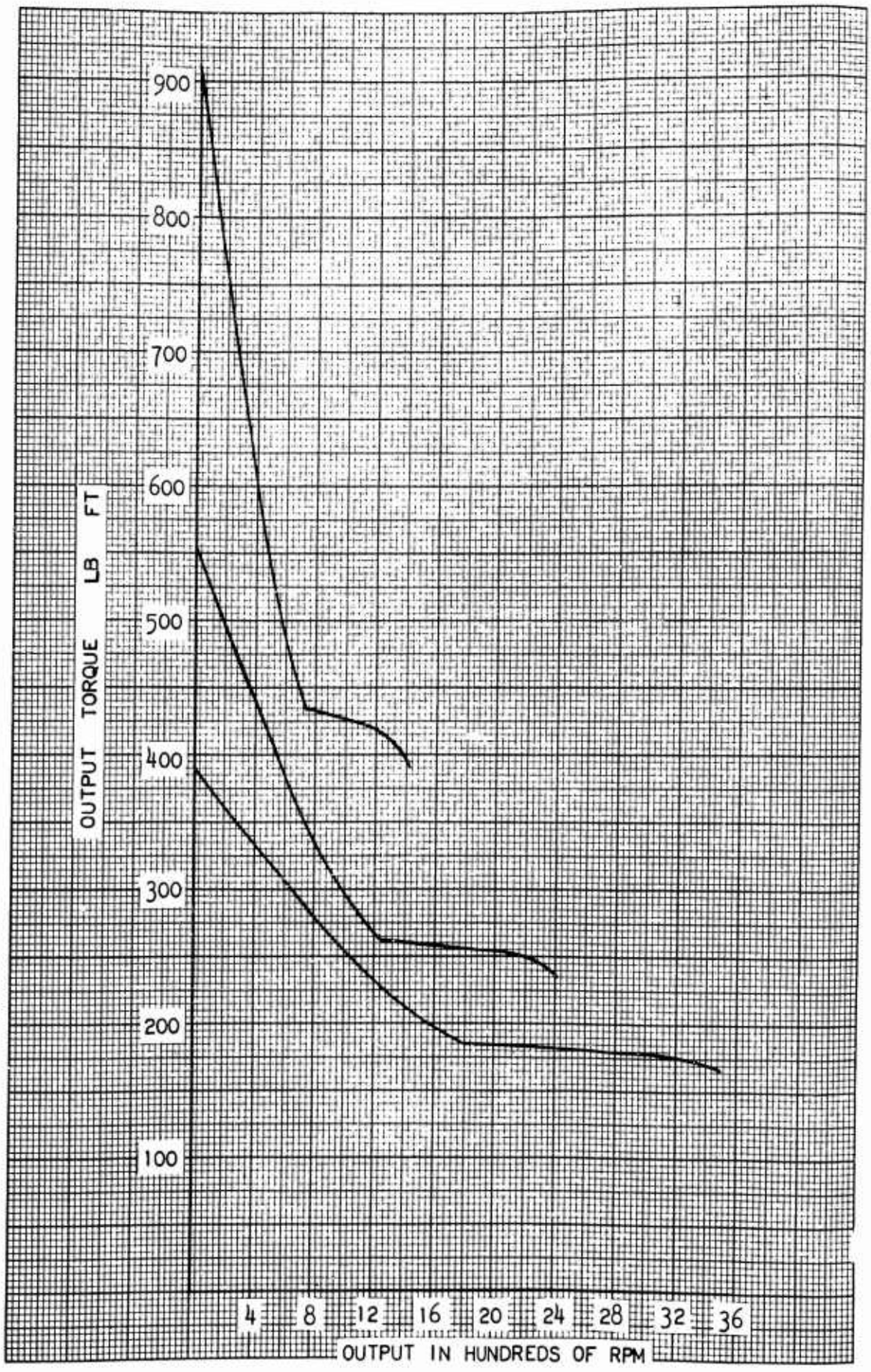


Figure A-3 Transmission Output

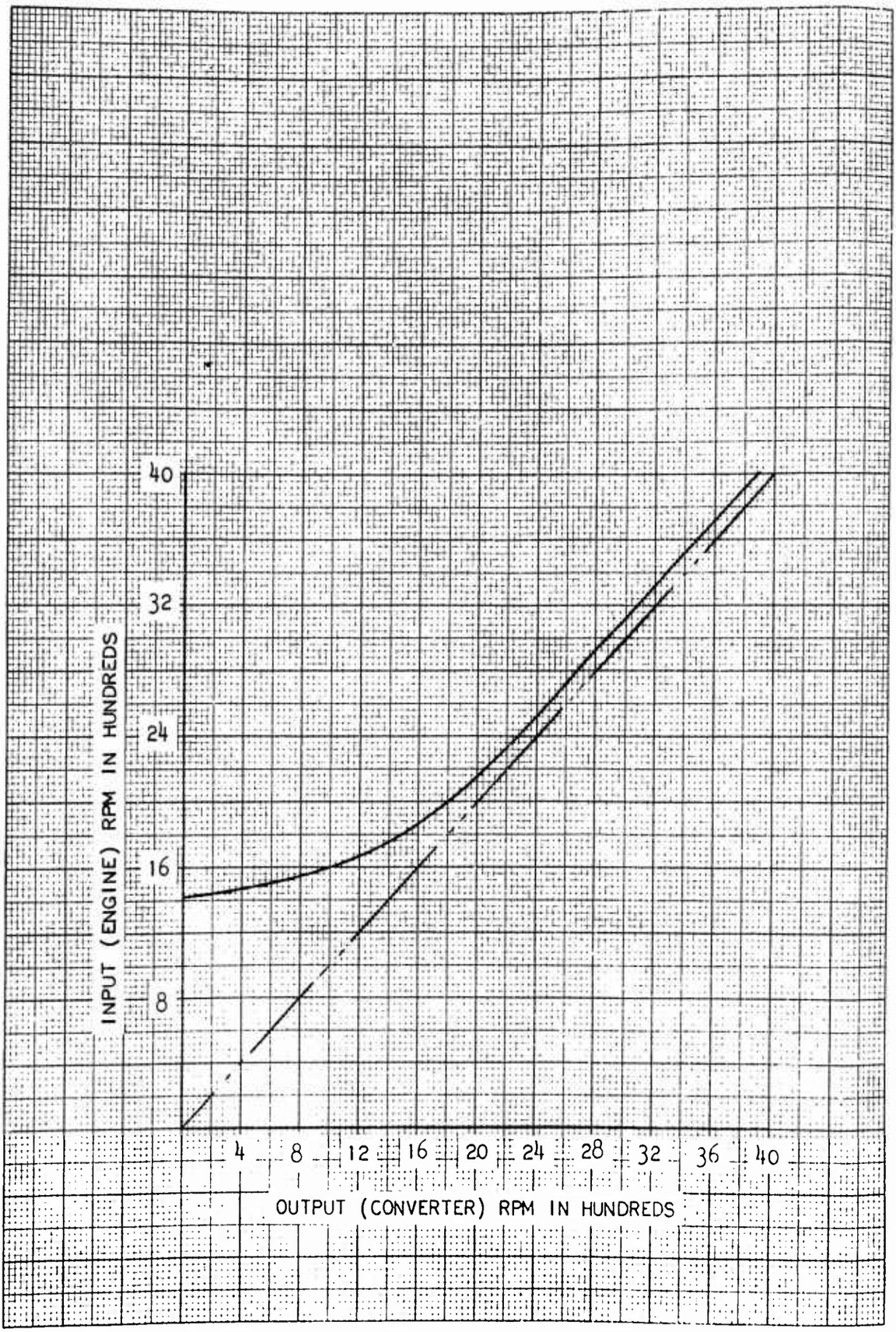


Figure A-4 Converter Characteristics

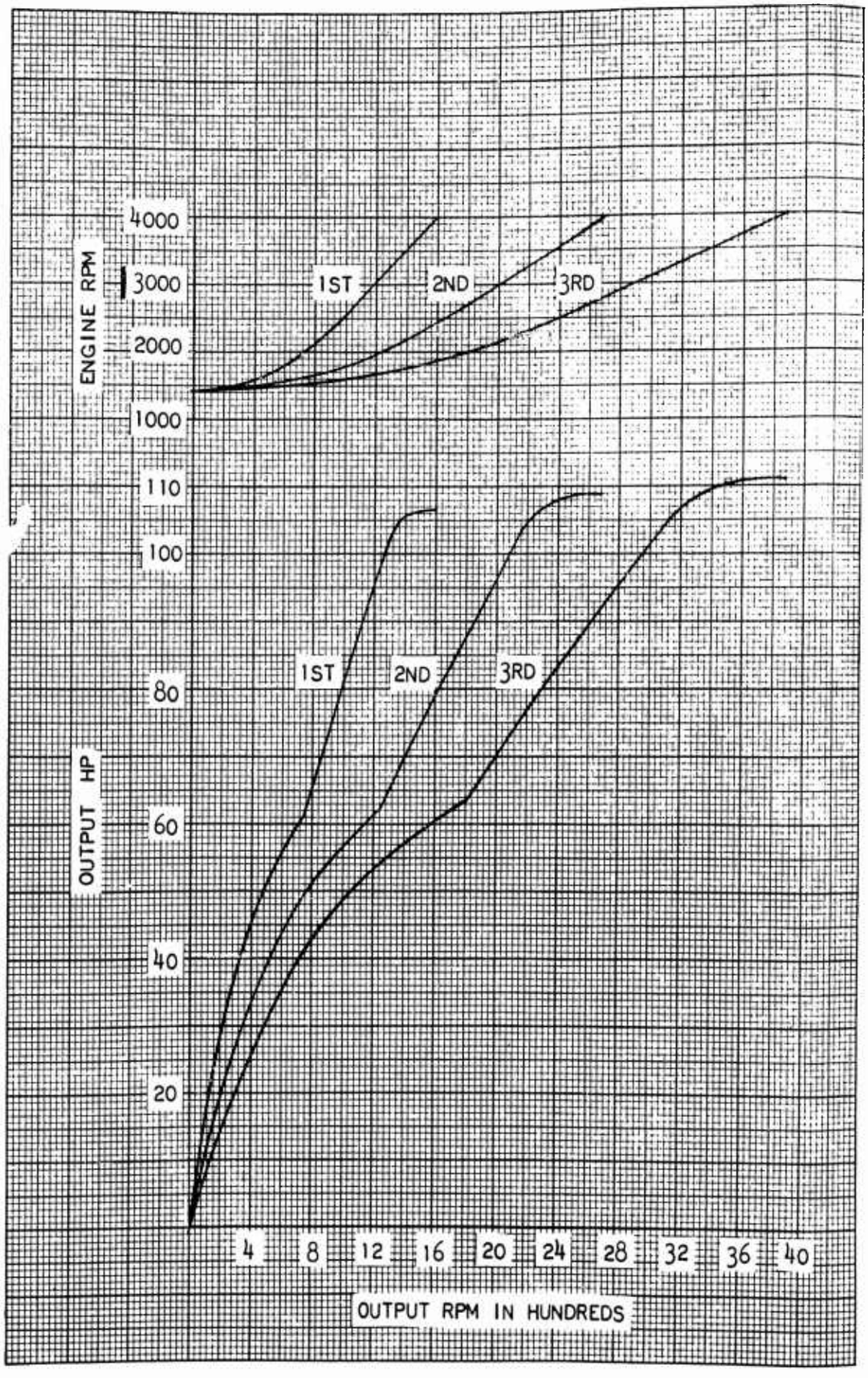


Figure A-5 Power Package Performance

APPENDIX B - WATER PERFORMANCE

Upon completion of the vehicle, it was taken to the Detroit River test site and water speed tests were run. The tests were conducted on 10 January 1963 in water at near freezing temperature. The area was ice covered in spots, but the launching area was clear enough to permit a 0.1 mile course to be marked off. Tests were run both upstream and downstream to cancel out the current effects. The average maximum speed during these tests was found to be 7.85 mph (11.54 fps) with one passenger and 7.95 mph (11.60 fps) with two passengers. Data Sheets B-1 and B-2 show the times recorded and the average speeds for each of the six tests performed.

On 6 and 7 February 1963, additional speed tests were conducted at the Louisiana test site. Runs were made in opposing directions to cancel out current and wind effects. The maximum average speed over a 264-foot course was: 9.83 mph (14.41 fps) with two men; 7.60 mph (11.16 fps) with a 1200-pound load and 40 gallons of gasoline; and 7.46 mph (10.95 fps) with the same load but with the weight shifted towards the bow. Data Sheets B-3 and B-4 show the results of these tests.

On 10 May 1963, additional maximum speed tests were run at the 15 Mile Road test site. Again, the tests were run in opposing directions to cancel out wind effects. During these tests, the vehicle carried five men and approximately 150 pounds of electronic instrumentation

used to determine horsepower requirements. (See Appendix F.) The maximum average speed recorded during these tests was 7.56 mph (11.10 fps). The results of these tests are shown on Data Sheet B-5.

The last series of water speed tests were run on 21 June 1963 at the Detroit River test site. These tests were conducted with a crew of one and with a crew of six, and with the transmission in "2" and "D." Runs were made in opposing directions and a total of 20 runs were made during this test phase. With one man aboard, the maximum average speeds were: 7.60 mph (11.1 fps) with the transmission in "2," and 6.95 mph (10.2 fps) with the transmission in "D." With six men aboard, the maximum average speeds were: 6.70 mph (9.83 fps) with the transmission in "2," and 5.78 mph (8.46 fps) with the transmission in "D." Data Sheets B-6 and B-7 show the measured times and computed speeds.

The maximum average speed with one man or fully loaded and operating in "2" is tabulated below for ease of comparison.

DATE	CREW	SITE	SPEED IN MPH
1-10-63	1	Detroit River	7.85
2-6-63	1	Louisiana	9.83
6-21-63	1	Detroit River	7.60
			8.42 Average
2-6-63	Full	Louisiana	7.60
2-7-63	Full	Louisiana	7.46
5-10-63	Full	15 Mile Road	7.56
6-21-63	Full	Detroit River	6.70
			7.33 Average

3025 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 1-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS WATER SPEED TESTS IN THE DETROIT RIVER. ONE PASSENGER.

.1 MILE COURSE TRANSMISSION IN "2".

DIRECTION	TIME IN SECS.	FT. PER SECS.	MILES PER HOURS
Down Stream	41.5	12.75	8.68
Upstream	49.8	10.62	7.24
Downstream	40.2	13.15	8.95
Upstream	55.2	9.59	6.54
Downstream	39.2	13.48	9.18
Upstream	55.0	9.63	6.55
Average		11.54	7.85

NOTE: Freeboard = 39 inches at bow and 25.5 inches at stern.

TESTED BY: C. G. Wells

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 2 DATE 1-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS WATER SPEED TESTS IN THE DETROIT RIVER. TWO PASSENGERS.
.1 MILE COURSE TRANSMISSION IN "2".

DIRECTION	TIME IN SECS.	FT. PER SECS.	MILES PER HOUR
Upstream	59.8	9.82	6.69
Downstream	38.9	13.60	9.05
Upstream	55.2	9.59	6.52
Downstream	38.8	13.62	9.29
Upstream	51.5	10.25	6.99
Downstream	40.0	13.22	9.0
Average		11.68	7.93

TESTED BY: D. Kersey

3925 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 3 DATE 2-6-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL _____ SERIAL _____

REMARKS WATER SPEED TESTS IN LOUISIANA. 264 FT COURSE (1/20 MILE)
WATER TEMP. 46°F WIDE OPEN THROTTLE, TRANSMISSION IN "2".

DIRECTION	LOAD	TIME IN SECS.	FT. PER SEC.	MILES PER HOUR
Upstream	1 Man	19.0	13.90	9.48
Downstream	1 Man	17.3	15.25	10.40
Upstream	1 Man	18.8	14.01	9.56
Downstream	1 Man	18.2	14.50	9.89
Average			14.41	9.83
Upstream	2 Men	19.2	13.75	9.37
Downstream	2 Men	21.0	12.55	8.56
Upstream	2 Men	19.5	13.52	9.22
Downstream	2 Men	19.5	13.52	9.22
Average			13.33	9.09

TESTED BY: M. Neumeyer

3025 REV. 6-48

LABORATORY TEST SHEET

TEST NO. 4 DATE 2-6-63 & 2-7-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL _____ SERIAL _____

REMARKS WATER SPEED TESTS IN LOUISIANA. 264 FT. COURSE (1/20 MILE).
WATER TEMP 46°F WIDE OPEN THROTTLE, TRANSMISSION IN "2".

	DIRECTION		LOAD		TIME IN SECS.	FT. PER SEC.		MILES PER HOUR	
	Upstream		1200 lbs.		23.0	11.49		7.83	
	Downstream		40 gals gas		24.0	11.00		7.50	
	Upstream				23.9	11.04		7.52	
	Downstream				23.8	11.08		7.56	
	Average					11.16		7.50	
*	Upstream		1200 lbs.		24.5	10.78		7.34	
*	Downstream		40 gals gas		24.1	10.94		7.45	
*	Upstream				23.4	11.28		7.69	
*	Downstream				24.5	10.78		7.34	
	Average					10.95		7.46	

NOTE: The weight was redistributed during these tests by moving eight sandbags toward the bow of the vehicle.

TESTED BY: M. Neumeyer

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 5 DATE 5-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS WATER SPEED TEST AT 15 MILE ROAD TEST SITE. 5 MEN PLUS INSTRUMENTATION IN VEHICLE. 500 FT. COURSE.

DIRECTION	TIME IN SECS.	FT. PER SEC.	MILES PER HOUR
South	45	11.1	7.56
North	45	11.1	7.56
Average		11.1	7.56

TESTED BY: C. G. Wells

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 6 DATE 6-21-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS WATER SPEED TESTING AT THE DETROIT RIVER TEST SITE. WIDE OPEN THROTTLE OPERATION 528 FT. (.1 MILE) COURSE.

DIRECTION		CREW		RANGE		TIME IN SECS.		FT. PER SEC.		MILES PER HOUR	
Upstream		6		2		66.2		7.99		5.45	
Downstream		6		2		42.6		12.41		8.47	
Upstream		6		2		65.4		8.09		5.52	
Downstream		6		2		42.4		12.45		8.50	
Upstream		6		2		64.3		8.22		5.60	
Downstream		6		2		41.8		12.64		8.63	
Average								9.83		6.70	
Upstream		6		D		77.8		6.79		4.63	
Downstream		6		D		46.5		11.38		7.76	
Upstream		6		D		78.2		6.76		4.61	
Downstream		6		D		47.5		11.11		7.58	
Average								8.46		5.78	

TESTED BY: C. G. Wells

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 7 DATE 6-21-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS WATER SPEED TESTING AT THE DETROIT RIVER TEST SITE. WIDE OPEN THROTTLE OPERATION. 528 FT. (.1 MILE) TEST COURSE

DIRECTION	CREW	RANGE	TIME IN SEC.	FT. PER SEC.	MILES PER HOUR
Upstream	1	2	51.5	10.25	7.00
Downstream	1	2	42.0	12.59	8.58
Upstream	1	2	54.7	9.65	6.68
Downstream	1	2	42.8	12.35	8.42
Upstream	1	2	54.5	9.71	6.62
Downstream	1	2	42.0	12.59	8.58
Average				11.1	7.60
Upstream	1	D	60.2	8.78	5.98
Downstream	1	D	44.0	12.01	8.20
Upstream	1	D	60.4	8.75	5.96
Downstream	1	D	42.7	12.38	8.44
Average				10.2	6.95

TESTED BY: C. G. Wells

APPENDIX C - EFFECT OF WATER SHROUD

1. PURPOSE OF TEST

The purpose of this test was to determine if shrouding rotors would increase water speed. (See Figure C-1.)

2. RESULTS OF TEST

The addition of shrouding over the rotors did not give increased water speed.

3. DISCUSSION

The test of the Marsh Screw Amphibian was conducted on 3 June 1963 at the Chrysler property located north of 15 Mile Road and west of Van Dyke. All runs were made South-North direction and were timed over a measured one-tenth of a mile course as marked by white stakes on the shore. The average speed recorded over this measured course was as follows:

		NORMAL	WITH SHROUD
Loaded	2nd	7.15 mph	7.09 mph
	3rd		6.71 mph
2 Men	2nd	7.7 mph	7.25 mph
	3rd	6.78 mph	6.92 mph

For the loaded condition, four men at 720 pounds, plus six bags of sand eighty pounds each, for a total of 1200 pounds, were used for the loaded runs with the shrouding. The loaded runs without shrouding were done with three men at 560 pounds plus eight bags for a total of 1200 pounds. In both runs unloaded, two men at 360 pounds were aboard the Marsh Screw Amphibian.

The vehicle showed a tendency to turn to the right when operated with the shrouding. To correct this, intermittent steering to the left was necessary.

When the vehicle was operated without shrouding, it exhibited a much better straight-ahead tendency with less steering corrections required.

4. RECOMMENDATIONS

Since the only advantage observed while operating with the shrouded version was that less splashing occurred, it is suggested that no further testing or consideration be given to vehicle shrouding within the scope of the present studies.

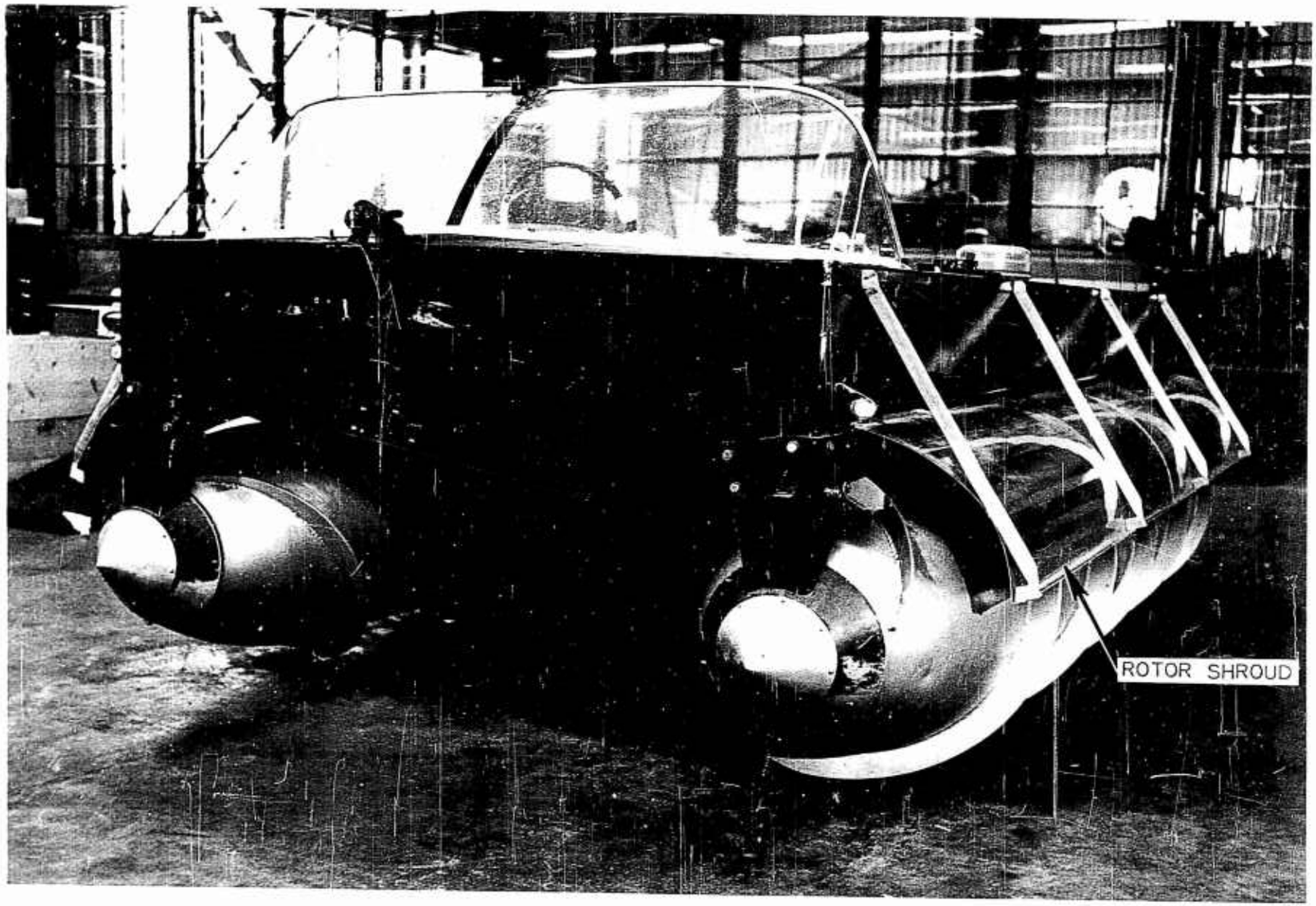


Figure C-1 Rotor Shrouds

APPENDIX D - TOWING RESISTANCE AND STATIC THRUST

On 21 June 1963, a series of towing resistance tests were run. The vehicle was towed by a 32-foot Chrysler Corporation launch at various speeds while measuring the towing force. The force was measured with a Baldwin Lima Hamilton SR4 load cell and indicator. The vehicle speed was determined by measuring the time required to traverse a 0.1-mile course. Tests were run in opposing directions to cancel out current and wind velocity effects and the same course was followed by use of landmarks and a compass. The data obtained is shown on Data Sheet D-1. During this test, 5 men were aboard the vehicle.

From the data on Data Sheet D-1, a plot of the force required to overcome towing resistance and the power required to sustain the indicated speeds was made on Figure D-1. The horsepower indicated was computed from the force and velocity measurements:

$$HP = \frac{FV}{550}$$

Figure D-2 is a plot of the data on Data Sheet D-3, which is also given in Appendix F, and the towing resistance curve for comparison purposes. Also given on this curve is a plot of propulsive efficiency:

$$\% \text{ Eff} = \frac{\text{power to tow}}{\text{power to propel}} \times 100$$

This plot assumes that the attitude of the vehicle while being towed is the same as while operating under its own power, and that permitting the rotors to spin freely while being towed negates the possibility of a difference in drag characteristics during the tow tests. The propulsive efficiency, through the speed range of 4 to 12 fps, was a maximum of 75 per cent at the low speed and 20 per cent at the higher speeds. The curve flattens out at 6 through 12 fps and indicates almost a constant 20 per cent through this range. Towing eyes, as shown in Figure D-3, were installed for this test.

In addition to this test, a static thrust test was run with the vehicle operating at wide open throttle with one man and with five men. A maximum static thrust was obtained with five men aboard and with the transmission in "2." The horsepower developed was the maximum available or 110 hp. Data Sheet D-2 is a tabulation of this data.

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 1 DATE 6-21-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Towing Resistance of vehicle with 5 men aboard. 528 ft. course

	Time in sec	Ft. per sec	Miles per hour	Force in lbs	Ft-lb. sec	H.P.
Upstream	107.5	4.93	3.35	363		
Downstream	58.2	9.09	6.20	485		
Average		7.18	4.87	424	3040	5.65
Upstream	83.6	6.31	4.32	525		
Downstream	48.6	10.9	7.45	525		
Average		8.62	5.88	525	4520	8.23
Upstream	67.4	7.87	5.36	738		
Downstream	41.1	12.85	8.80	738		
Average		10.36	7.08	738	7520	13.70
Upstream	56.4	9.39	6.40	1012		
Downstream	37.0	14.30	9.75	1012		
Average		11.80	8.07	1012	11920	21.70

TESTED BY: C. G. Wells

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 2 DATE 6-21-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Static thrust in water at 100% slip wide open throttle performance

	Crew		Range	Engine RPM		Thrust in lbs		HP			
	1		2	3700		678		110			
	1		D	2100		769		74			
	5		2			864					
	5		D			757					

TESTED BY: C. G. Wells

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 3 DATE 7-2-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS TABULATION OF DATA ON CURVE SHEET NO. 2 AND CALCULATED EFFICIENCY.

FEET PER SEC.	HORSE POWER PROPELLING	HORSE POWER TOWING	PERCENT OF EFFICIENCY
4	4	3	75
6	15	4	26.7
8	37.5	7.5	20.05
10	68.5	12.5	18.3
12	102 (Est.)	22.5	22.1

TESTED BY: C. G. Wells

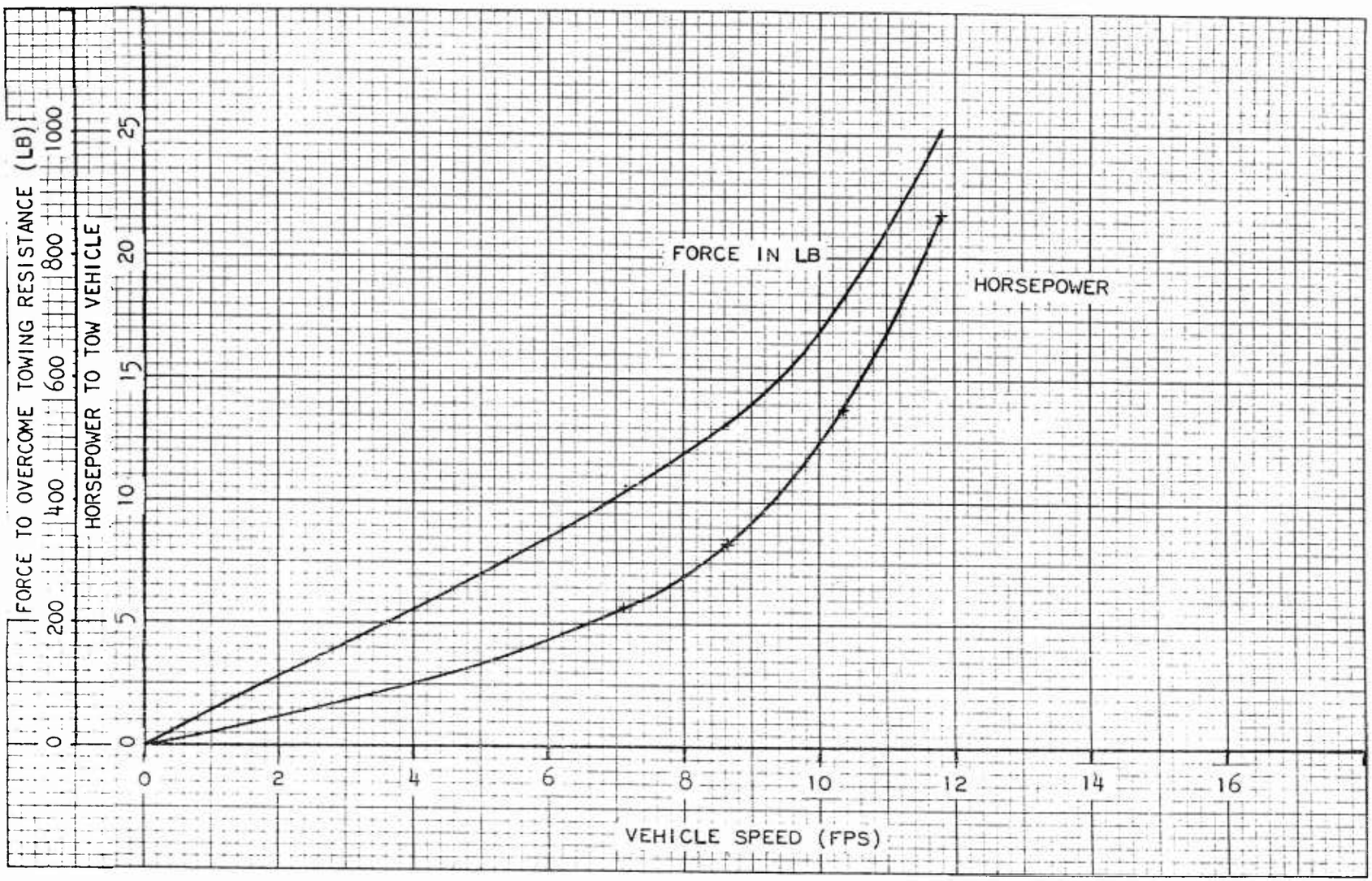


Figure D-1 Loaded Towing Resistance

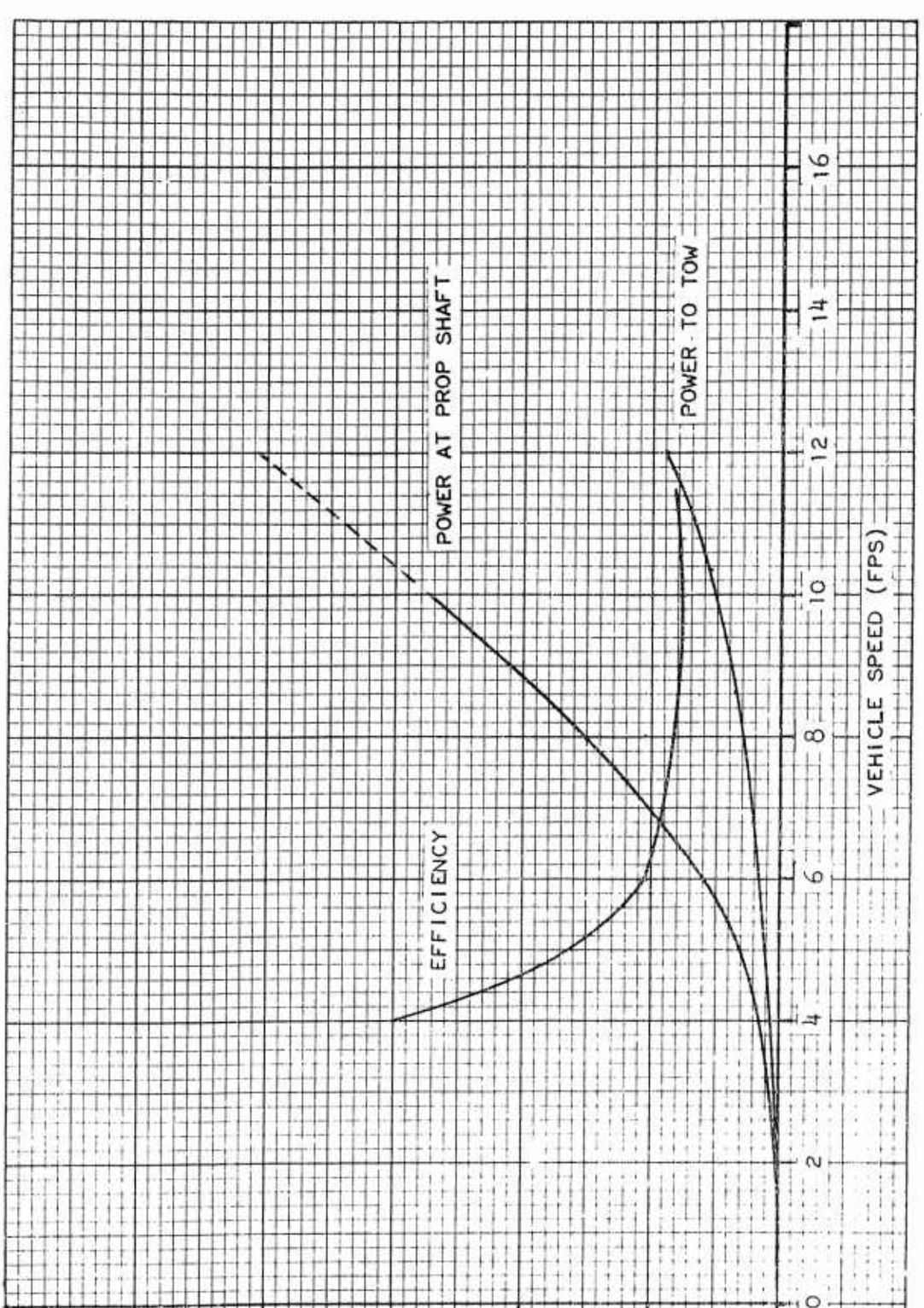


Figure D-2 Propulsion Efficiency

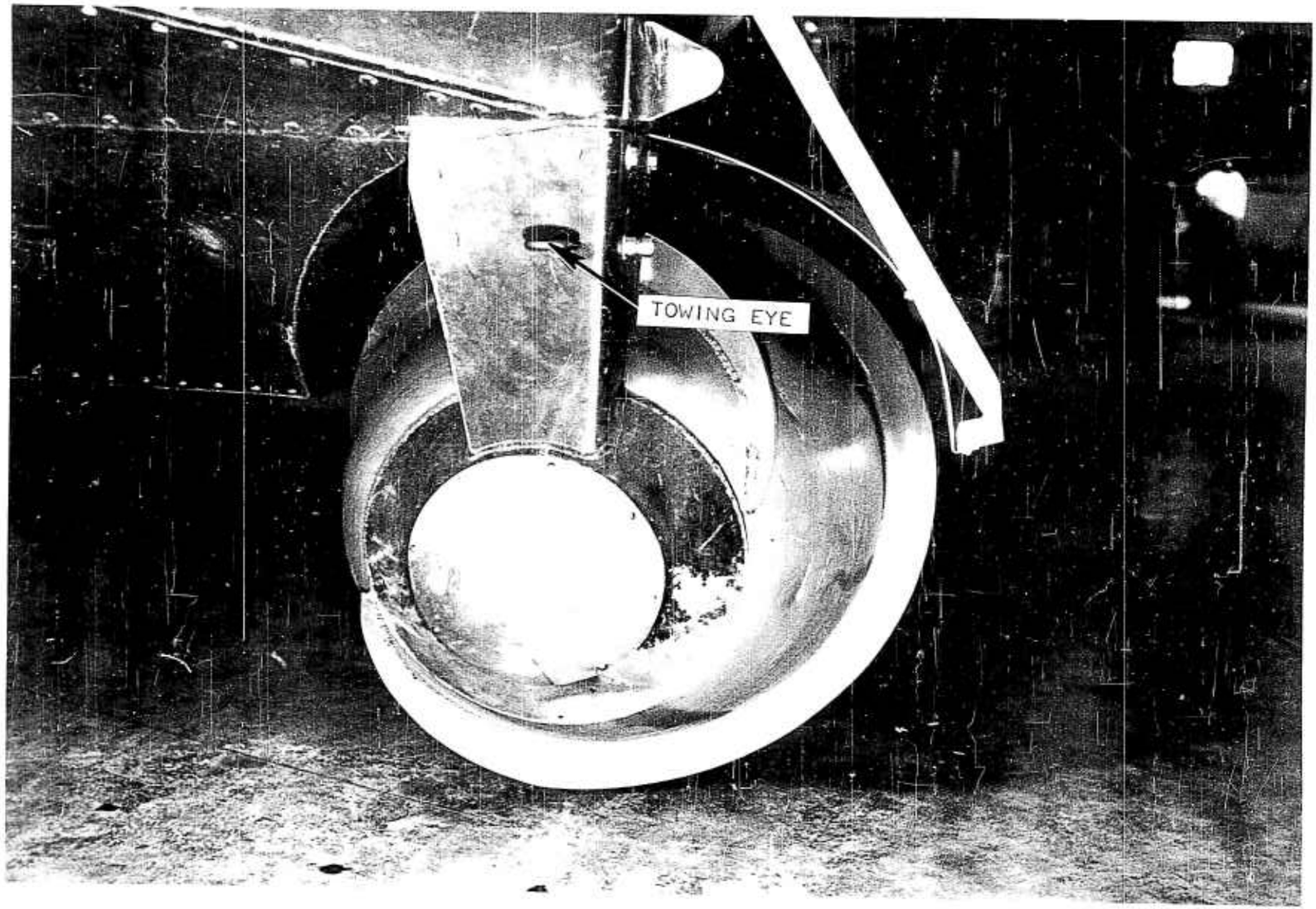


Figure D-3 Towing Attachments

APPENDIX E - VEHICLE PERFORMANCE ON TIDAL MUD

A series of wide open throttle speed tests were conducted in muddy bog with the vehicle operating over a 264-foot course with a full load. The first tests were conducted at Lee's Island on a muddy beach with a 5 per cent slope. The tests conducted at first showed greater speeds and after the mud was disturbed the rotor slip increased and the maximum speed decreased. Data Sheet E-1 is a compilation of the data taken during the muddy bog tests and indicates a maximum speed of 14.5 fps (9.88 mph). Data Sheet E-2 is a compilation of vehicle data obtained from Figure E-1. This data gives an approximation of load and slip during the tests. Note the increase in slip at the later tests.

Figure E-1 is a theoretical curve based on the performance of the power train and various rotor slip factors. The muddy bog operating point is shown. This curve also illustrates how vehicle velocity can vary greatly according to ground conditions.

The next mud tests were also run at Lee's Island, but were run in a "bottomless" mud area. The condition of the area prevented setting up a test course, but engine data was recorded and the apparent rotor slip was observed and calculated to be less than 5 per cent. The data is entered on Data Sheet E-3.

Figure E-2 is similar to Figure E-1 with the exception of a wider vehicle speed scale. The tidal mud operating point is shown, and the resulting vehicle speed indicated is 33 fps.

(23.2 mph). The correlation between observed data and data derived from these curves indicates a reasonable degree of accuracy is obtained, and also permits performance predictions to be made when an operating point is established.

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 2-8-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS VEHICLE SPEED IN MUDDY BOG

264 FT. COURSE, FULL LOAD.

DIRECTION		RANGE		ENGINE RPM	PROP. SHAFT HP	TIME IN SEC.		FT. PER SEC.		MILES PER HOUR	
Rt		1		3500	106	18.3		14.4		9.82	
Lt		1		3500	106	18.2		14.5		9.88	
Lt		2		1850	59	21.8		12.1		8.25	
Rt		2		1850	59	22.7		11.65		7.95	
Lt		D		1500	35	34.5		7.65		5.22	
Rt		D		1500	35	37.8		6.98		4.77	
Lt		1		3800	106	19.0		13.85		6.45	
Rt		1		3800	106	24.5		10.75		7.32	

TESTED BY: M. Neumeyer

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 2 DATE 7-2-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS TABULATION OF MUDDY BOG TEST DATA AND COMPUTED SLIP DATA FULL LOAD.

ENGINE RPM		RANGE	HP	OUTPUT RPM			ACTUAL FPS		% SLIP		
3500		1	106	1400			14.4		0		
3500		1	106	1400			14.5				
1850		2	59	1080			12.1		0		
1850		2	59	1140			11.65				
1500		D	35	1100			7.65		35		
1500		D	35	1100			6.98				
3800		1	106	1500			13.85				
3800		1	106	1800			10.75		20		

TESTED BY: C. G. Wells

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 3 DATE 3-8-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS TIDAL MUD TESTING

Engine Speed 3500 to 3600 rpm

Transmission in "D"

Rotor Slip Pattern = 1-2 inches

Rotor Slip (Calculated) = 2.08 to 4.17%

Prop Shaft Torque (From Engine Curves) = 175 lb ft

Prop Shaft Speed (From Curve Sheet No. 7) = 3400 rpm

Vehicle Speed (From Curve Sheet No. 2) = 33 fps

or 23.2 mph

TESTED BY: M. J. Neumeyer

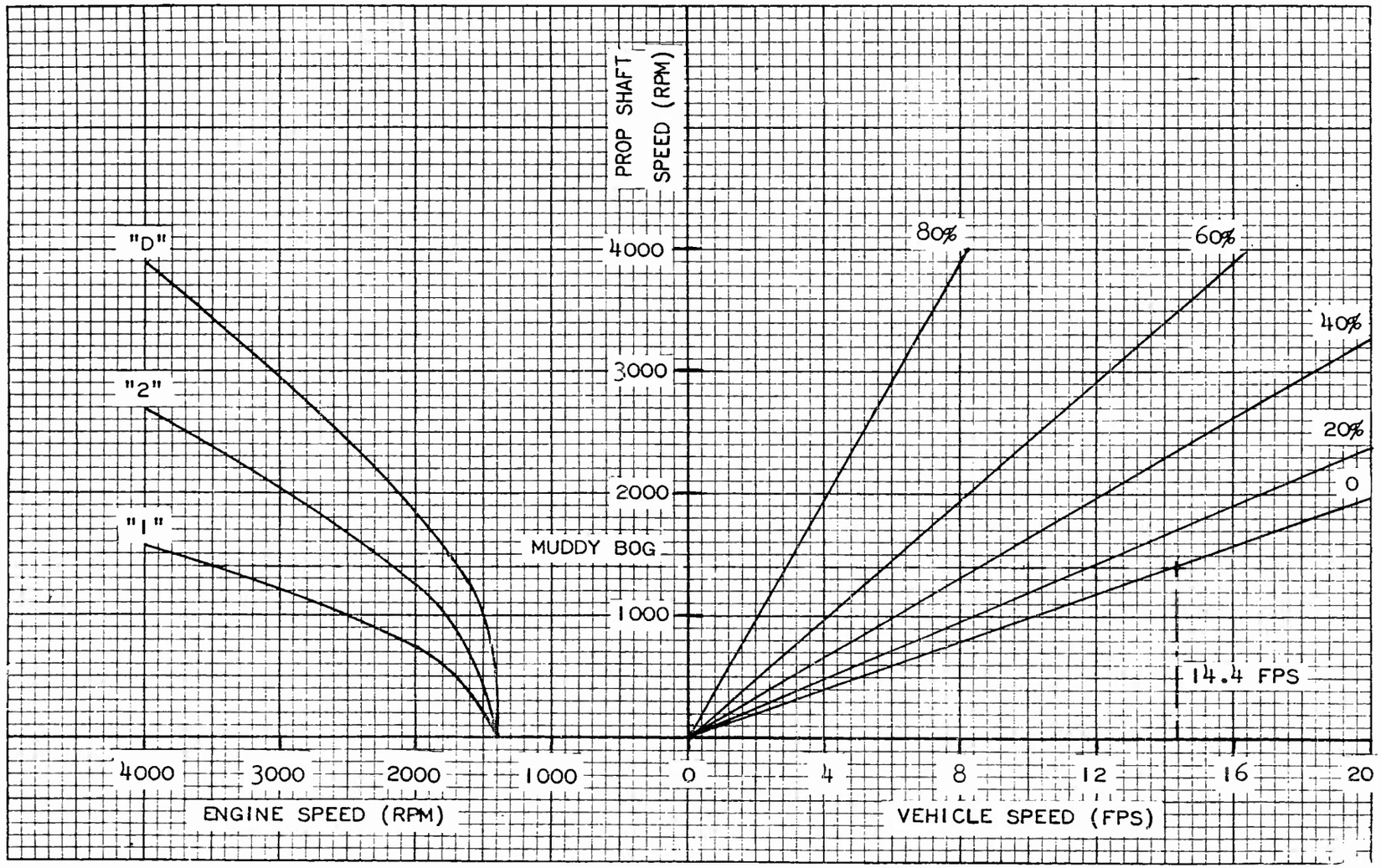


Figure E-1 Vehicle Speed Calculated from Rotor Slip and Engine RPM (Muddy Bog)

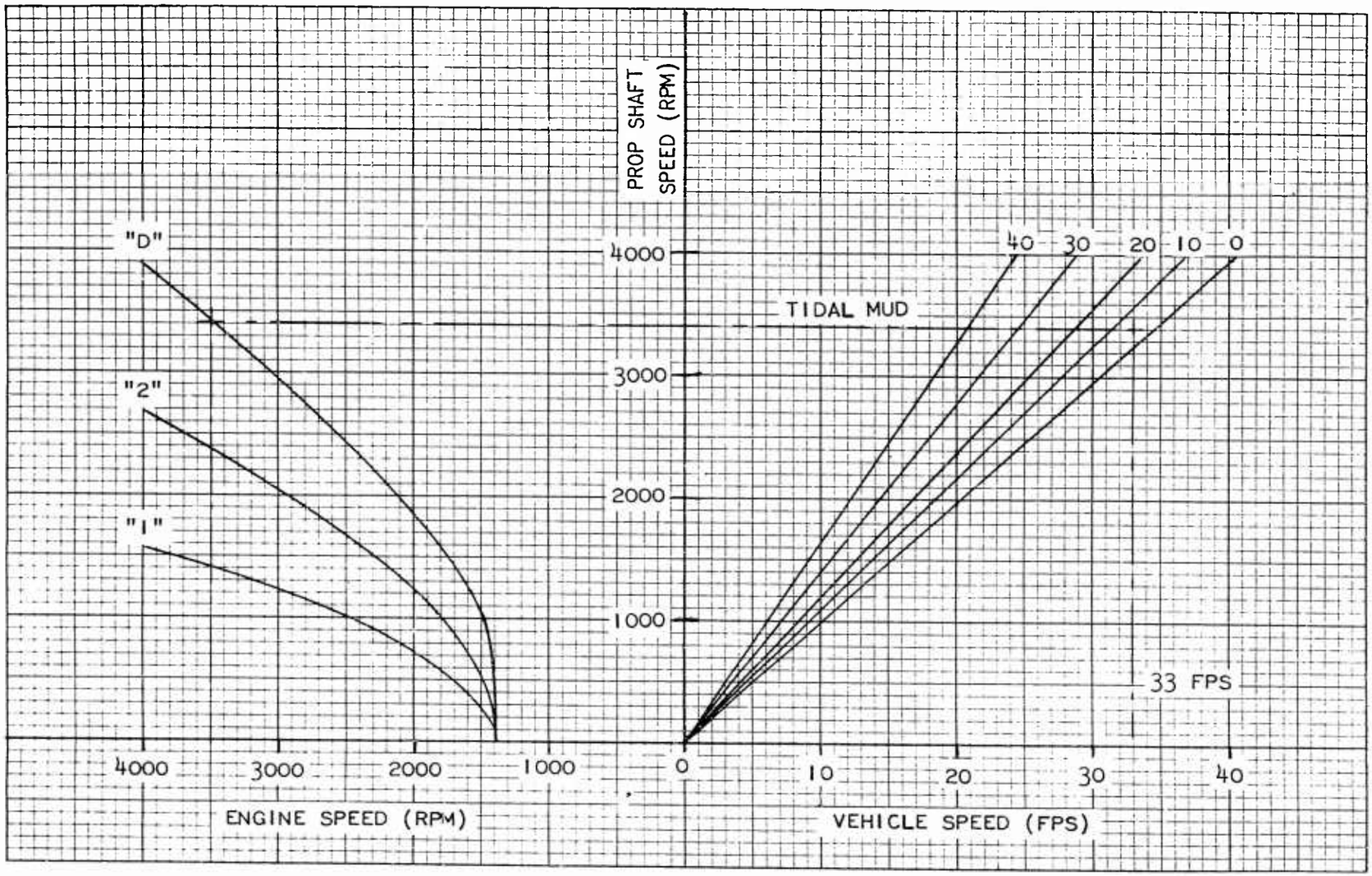


Figure E-2 Vehicle Speed Calculated from Rotor Slip and Engine RPM (Tidal Mud)

APPENDIX F - DETERMINATION OF POWER REQUIREMENTS

A series of tests were conducted in Louisiana to determine the relationship between vehicle speed and power during water testing. The first test was run to determine the relationship of engine rpm and water speed. This test was accomplished in Louisiana, and the data taken is shown on Data Sheet F-1 and Figure F-1. A curve is given with the transmission in "2" and "D."

The next tests were performed at the 15 Mile Road test site to determine the power at the transmission output shaft during various modes of operation. The vehicle was instrumented with strain gages on the output shaft, a slip ring, a shaft-speed indicator incorporating a magnetic pick-up, and a turbine-type water speed indicator The signals were fed into a C.E.C. recording oscillograph. The instrumentation is shown in Figures F-2, F-3, and F-4.

Data Sheets F-2 and F-3 are a reduction of the signals recorded with the oscillograph. Figure F-5 is a plot of prop shaft horsepower versus water speed with the vehicle carrying one man and instruments, two men and instruments, and five men and instruments. During this test, the maximum available horsepower was found to be 112, and the most desirable operation occurred with the transmission in "2." Figure F-6 is a plot of rotor slip versus speed. This plot shows considerable scatter, but the effect of loading the vehicle on slip and the approximate slip is shown.

A final test was performed to determine the torque required to operate the vehicle on sand or grass-covered sand. The same instrumentation, with the exception of the water speed indicator, was used. The data acquired is shown on Data Sheet F-4. The torque measured with the transmission in "1" was from 760 to 840 lb ft, and the vehicle was nearly stalled with the rotors turning at an extremely low speed.

3023 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 1 DATE 2-8-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS VEHICLE SPEED VS ENGINE SPEED TESTING

WATER TEMP = 46°F AMBIENT TEMP = 42°F

264 FT. COURSE - FULL LOAD

ENGINE RPM	RANGE	DIRECTION	TIME IN SEC.	FT. PER SEC.	MILE PER HOUR
3000	2	UPSTREAM	27.0	9.78	6.66
3000	2	DOWNSTREAM	26.0	10.15	6.93
2500	2	UPSTREAM	33.0	8.00	5.46
2500	2	DOWNSTREAM	31.0	8.52	5.82
2000	2	UPSTREAM	39.1	6.75	4.60
2000	2	DOWNSTREAM	38.0	6.95	4.74
1850	D	UPSTREAM	32.2	8.20	8.59
1850	D	DOWNSTREAM	30.1	8.78	5.98
1500	D	UPSTREAM	37.9	6.97	4.63
1500	D	DOWNSTREAM	40.4	6.54	4.56
1000	D	UPSTREAM	54.9	4.81	3.38
1000	D	DOWNSTREAM	50.6	5.22	3.65

TESTED BY: C. G. WELLS

3923 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 2 DATE 5-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS VEHICLE SPEED VS POWER TESTING AT 15 MILE ROAD TEST SITE

APPROX. 150 LBS. OF ELECTRONIC INSTRUMENTATION INSTALLED

ENGINE RPM	RANGE	CREW		PROP SHAFT RPM		PROP SHAFT TORQUE LB-FT		PROP SHAFT HP	% SLIP	WATER SPEED FT/SEC	MPH
1000	2	2		720		38		5.22	36.8	4.6	3.14
1500	2	2		1020		65		12.6	44.0	5.8	3.95
2000	2	2		1380		111		29.2	49.3	7.1	4.84
2500	2	2		1680		136		43.5	49.5	8.5	5.79
3000	2	2		1980		174		65.5	48.5	9.8	6.68
3500	2	2		2340		207		92.5	-	-	-
3600	2	2		2520		235		115	53.0	11.8	8.05
3800	2	2		2580		220		108	52.3	11.9	8.12
1000	D	5		840		52.2		8.35	25	5.1	3.47
1000	D	5		840		52.2		8.35	42.4	4.9	3.34
1500	D	5		1380		116		30.5	49.3	7.1	4.84
1500	D	5		1410		125		33.6	48.5	7.5	5.12
2000	D	5		1930		179		65.8	51.8	9.4	6.41
- INDICATES DEBRIS CAUSED THE WATER SPEED INDICATOR TO MALFUNCTION.											

TESTED BY: C. G. WELLS

3825 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 3 DATE 5-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL 1 SERIAL

REMARKS VEHICLE SPEED VS POWER TESTING AT 15 MILE ROAD TEST SITE.

APPROX. 150 LBS. OF ELECTRONIC INSTRUMENTATION INSTALLED

ENGINE RPM	RANGE	CREW		PROP SHAFT RPM		PROP SHAFT TORQUE LB-FT		PROP SHAFT HP	% SLIP	WATER SPEEDS FPS	MPH
(NOT TAKEN)	2	1		720		35.6		4.89	53	3.44	
	2	1		720		38.5		5.28	43.3	4.17	
	2	1		1080		79		16.3	57.2	4.71	
	2	1		1020		71.4		13.9	-	-	
	2	1		1440		117		32.2	-	-	
	2	1		1440		112		30.7	-	-	
	2	1		1800		144		49.4	58	7.64	
	2	1		1740		143		47.4	-	-	
	2	1		2100		176		70.4	63	7.95	
	2	1		2100		168		67.2	56	9.4	
	2	1		2640		211		106	-	-	
	2	1		2580		215		106	58	11.0	
	2	1		2640		216		109	-	-	
	2	1		2700		214		110	58	11.54	
	2	1		2700		216		112	57	12.1	
- INDICATES DEBRIS CAUSED THE WATER SPEED INDICATOR TO MALFUNCTION.											

TESTED BY: C. G. WELLS

3025 REV. 4-48

LABORATORY TEST SHEET

TEST NO. 4 DATE 5-10-63

PART TESTED MARSH SCREW AMPHIBIAN

MODEL _____ SERIAL _____

REMARKS DETERMINATION OF TORQUE AT PROP SHAFT DURING OPERATION ON DRY SAND. 5 MEN PLUS INSTRUMENTS. TRANSMISSION IN "1"

ENGINE RPM	TORQUE LB-FT.	PROP SHAFT RPM	REMARKS
1350	840	120	SAND OPERATION
1350	760	180	SAND OPERATION
1300	810	120	GRASS COVERED SAND OPERATION.

TESTED BY: C. G. WELLS

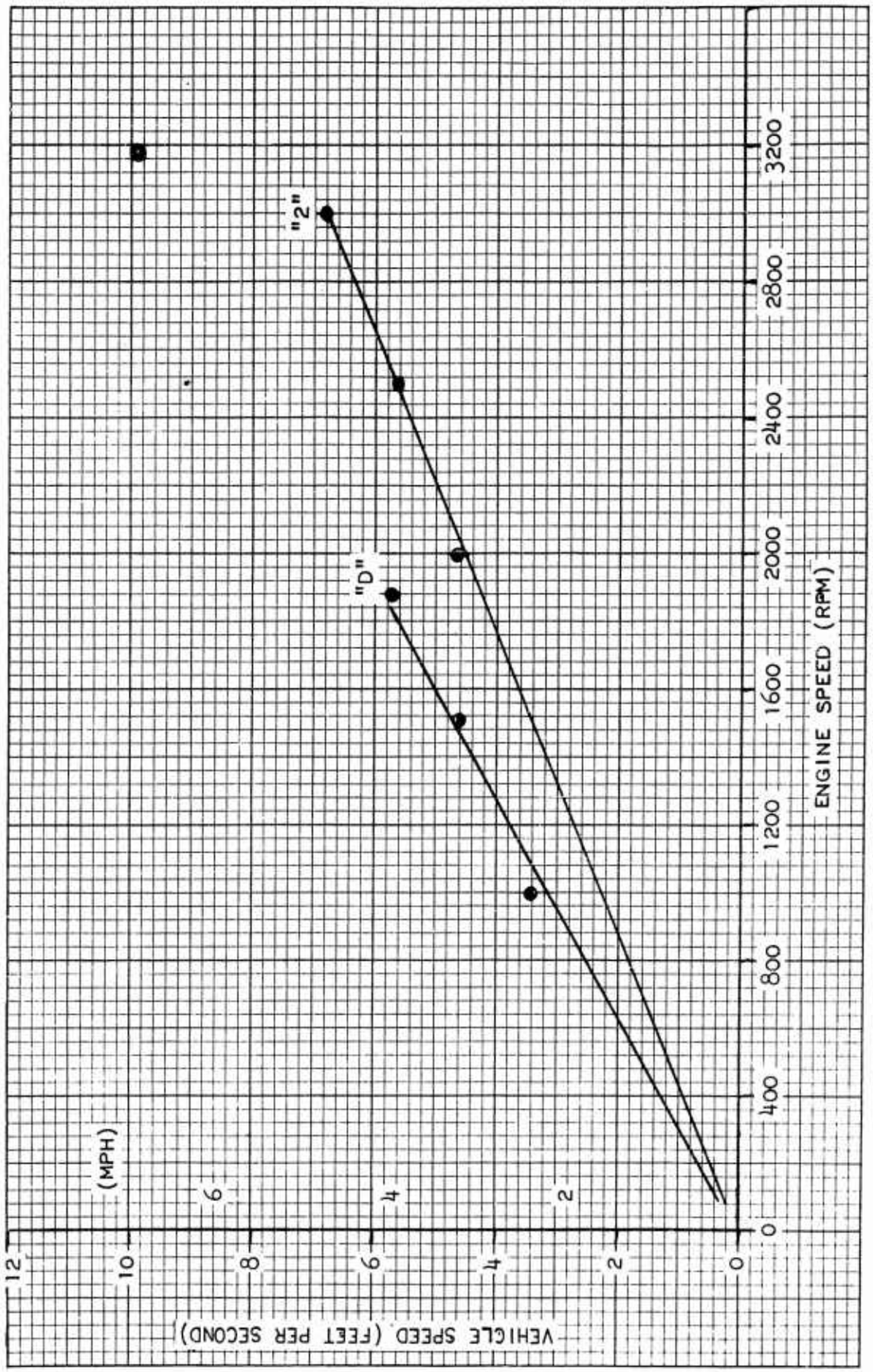


Figure F-1 Engine Speed vs. Water Speed

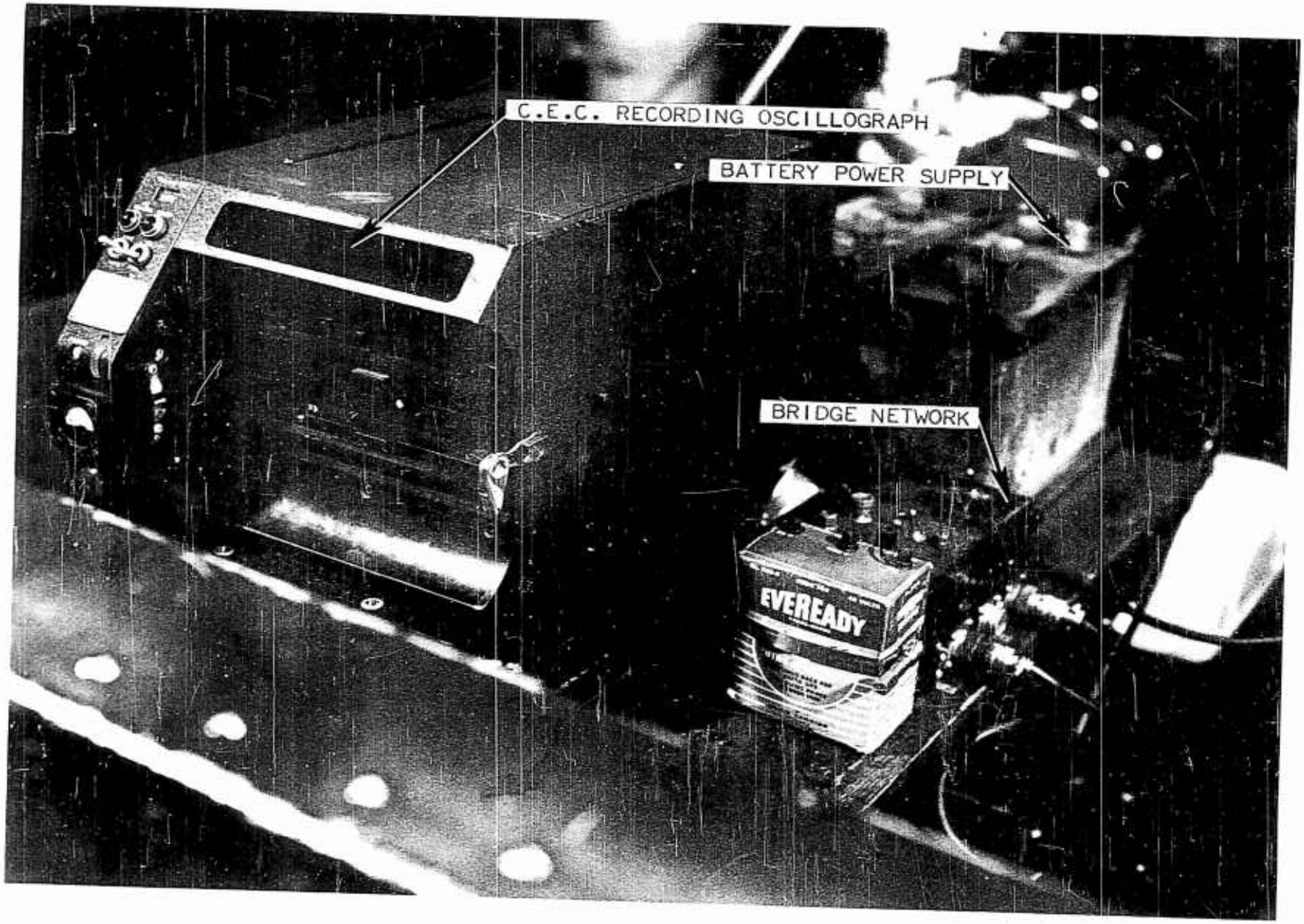


Figure F-2 Instrumentation for Power Requirements

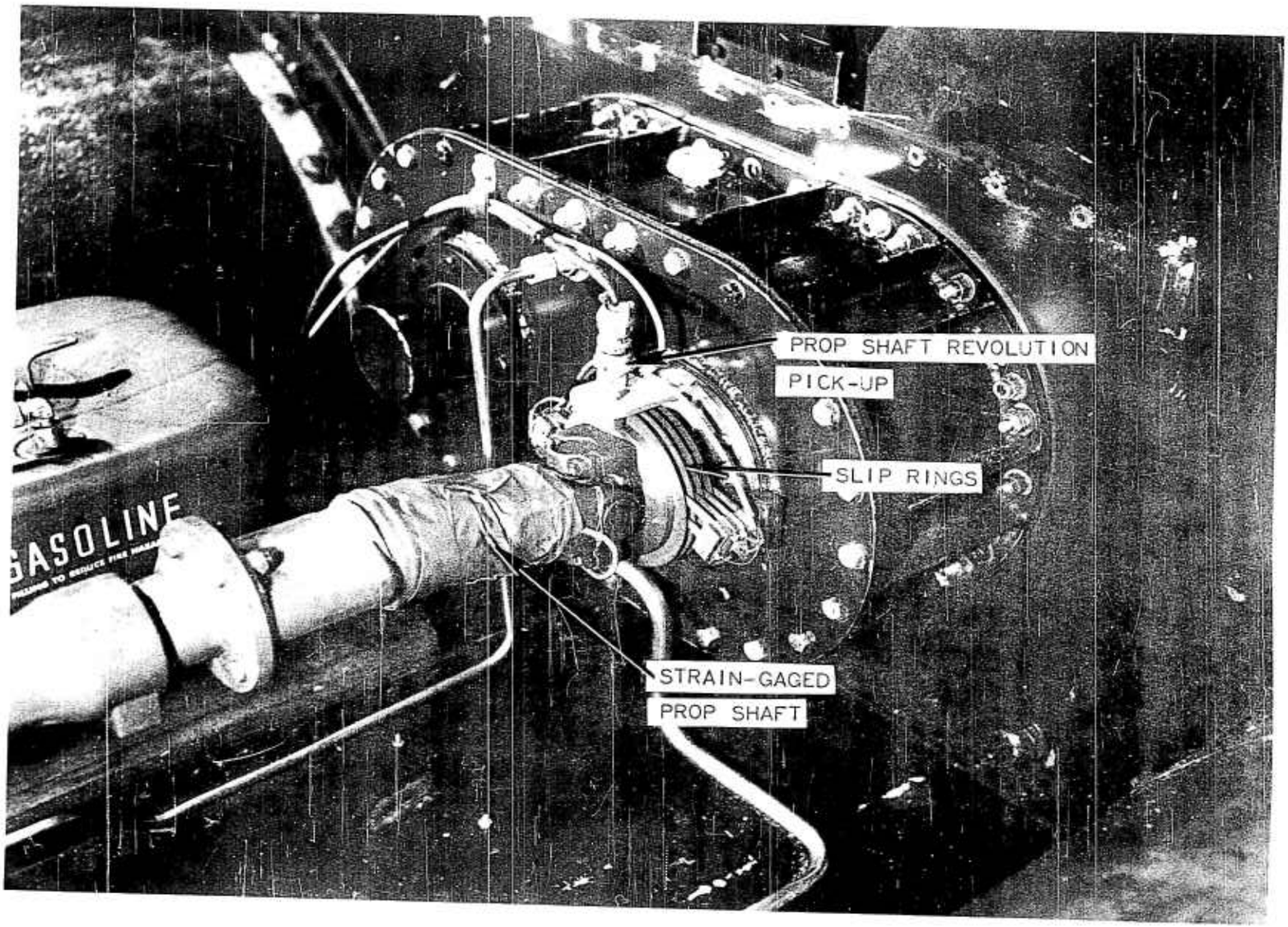


Figure F-3 Instrumentation for Power Requirements

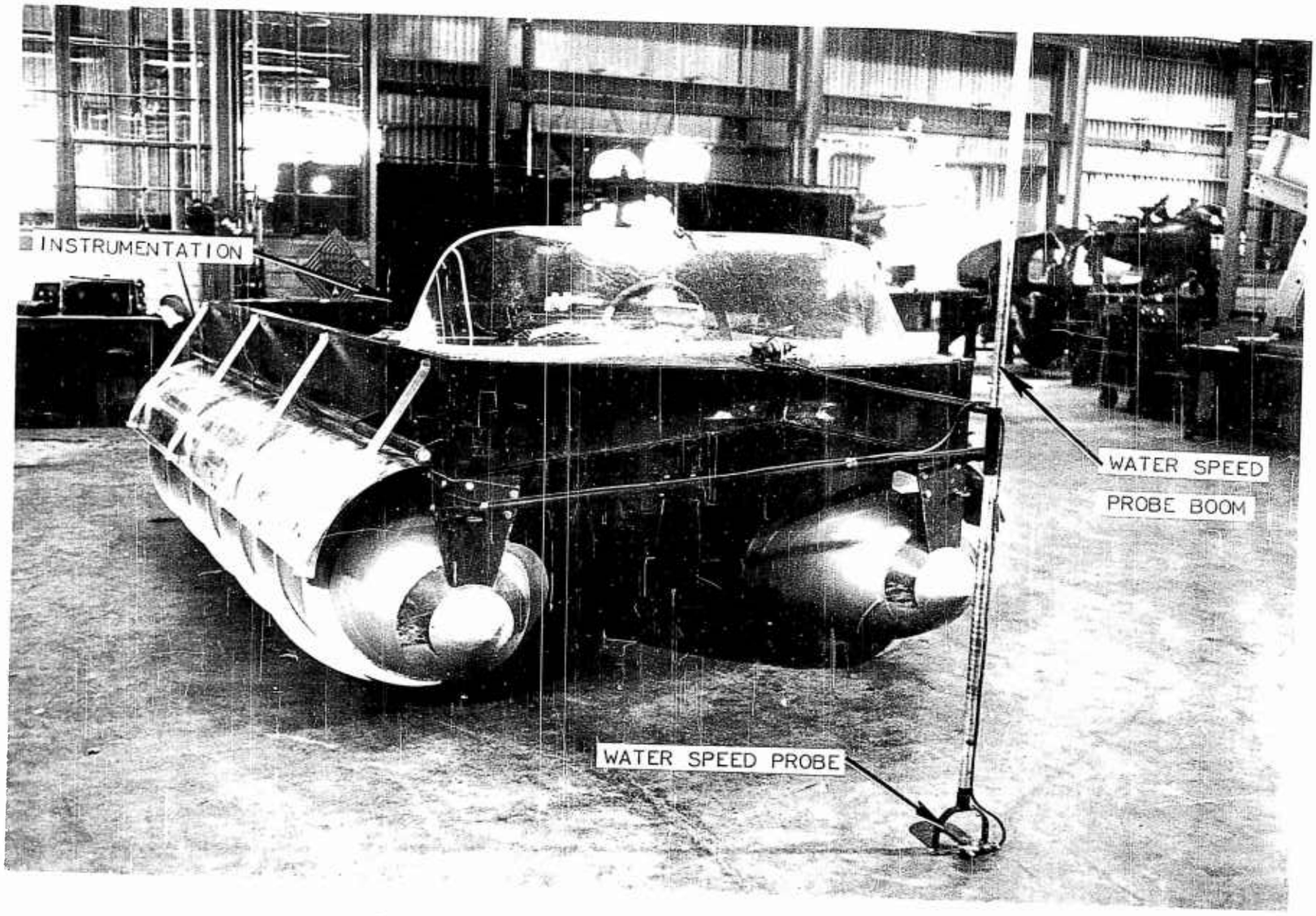


Figure F-4 Instrumentation for Power Requirements

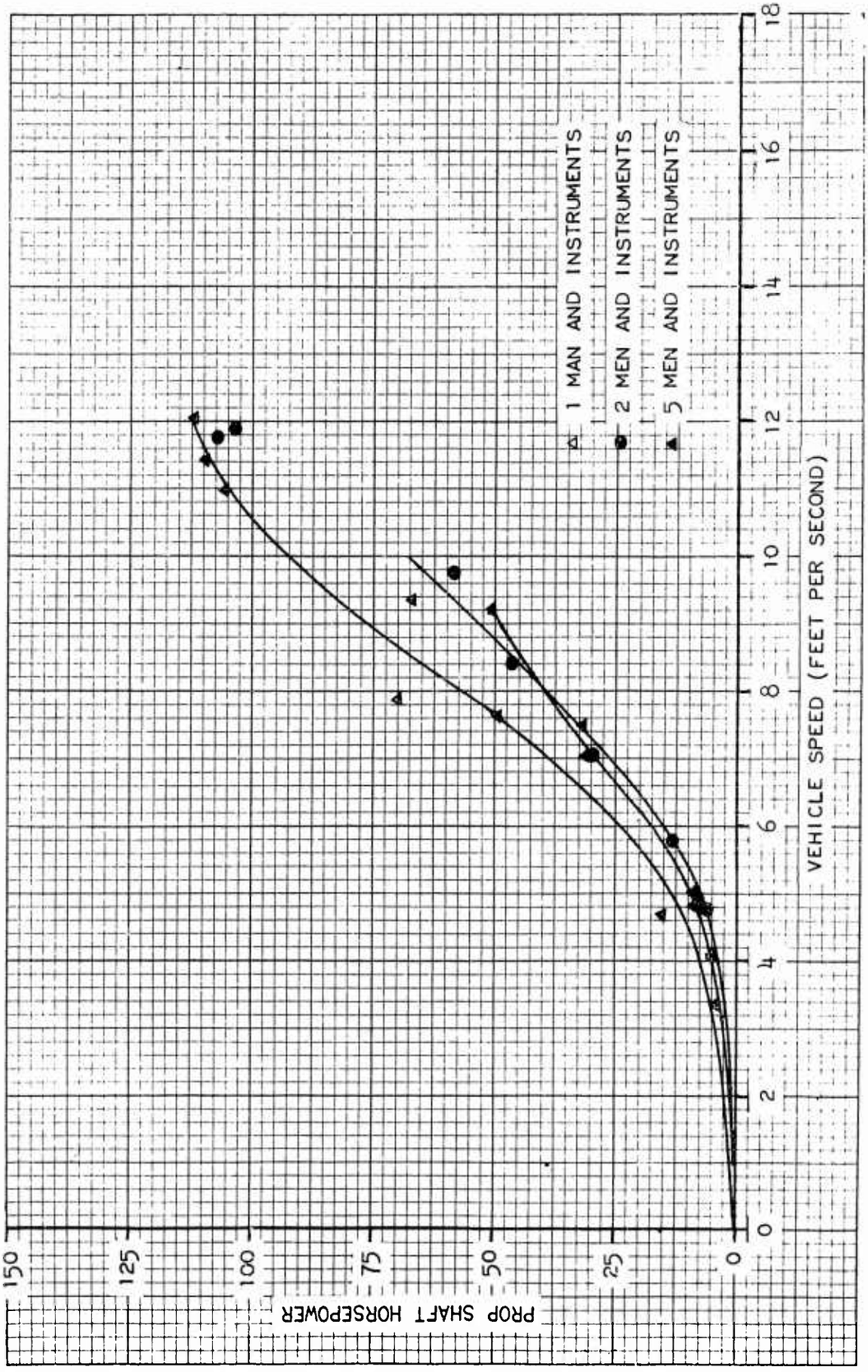


Figure F-5 Power Required for Propulsion

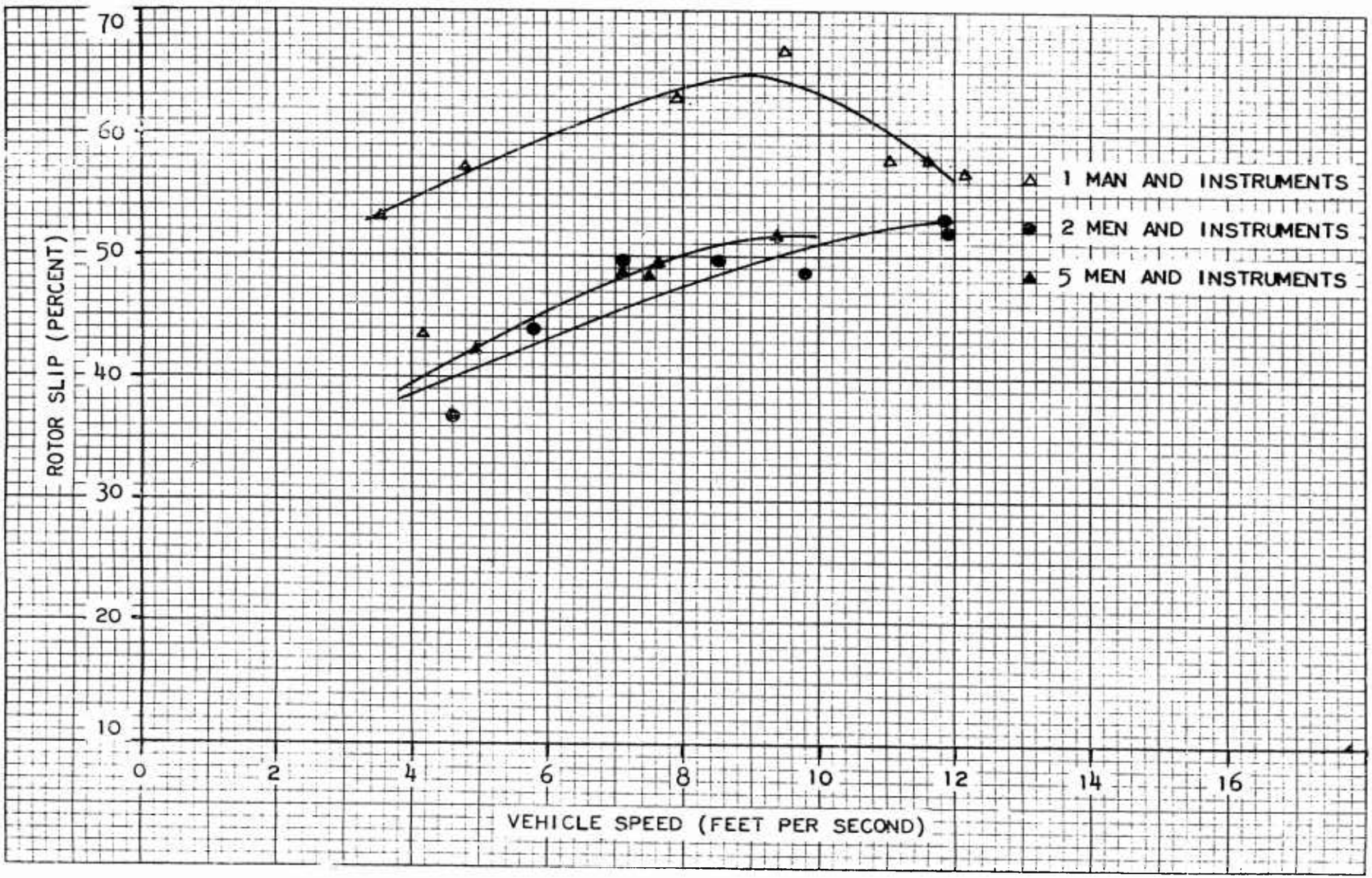


Figure F-6 Rotor Slip Characteristics

APPENDIX G - VEHICLE PERFORMANCE ON SNOW

On 24 January 1963, a series of snow mobility tests were run with a fully loaded vehicle. The tests were run at Chicora Corners in Allegan County, Michigan, in temperatures ranging from 0 to -20°F and in snow depths averaging 36 inches. The snow was blown and drifted with some encrustment due to thawing and freezing.

Motion picture records, rotor slip observations, and engine operating data was recorded. During this operation, the vehicle skimmed along on the surface of the snow at fairly high speeds, yet exhibited satisfactory braking and steering control. The engine was operated at wide open throttle with the transmission in "D," which resulted in an engine speed at approximately 3700 rpm. A performance curve, similar to that shown in Appendix E, was plotted and the snow operating point is shown in Figure G-1. Observations of rotor tracks indicated rotor slip of 0-2 per cent; therefore, 2 per cent was used to establish the operating point. The resulting speed, from the curve, is 35.8 fps (24.4 mph).

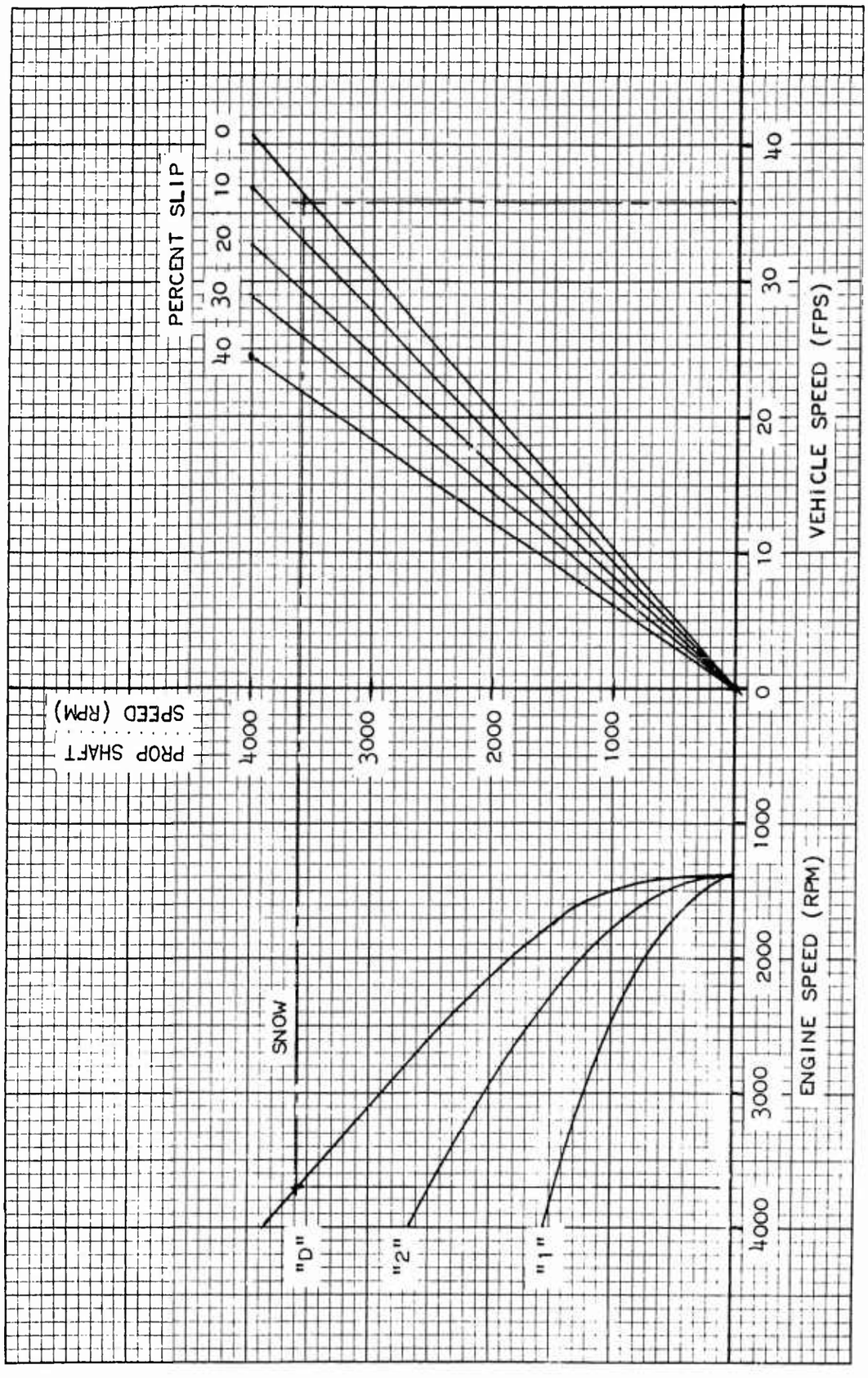


Figure G-1 Vehicle Speed Calculated from Rotor Slip and Engine RPM (Snow)

APPENDIX H - FUEL ECONOMY

On 21 June 1963 the average fuel consumption of the vehicle operating in the water was determined. The vehicle was launched at the Detroit River test site. Upon completion of other testing, the reserve tank used during testing was filled with six gallons of fuel; and the vehicle was operated at full power until the fuel supply was exhausted.

The course traveled consisted of leaving the launch site, traveling to the Belle Isle Bridge, and returning to the launch site. One direction was with the current and the other opposing. The course was 0.88 miles one way. The vehicle was able to make 2-3/4 round trips which totaled 4.85 miles. The average speed during this test was 5.28 to 5.95 mph. The time to consume 45 gallons of fuel was computed and found to be 6.0 hours. The computed distance to use 45 gallons of fuel was 36.5 miles. The data acquired during this test is shown in Data Sheet H-1.

3525 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 6-21-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Fuel consumption test. Five passengers and six gallons fuel.

Vehicle traveling from launch site to Belle Isle Bridge (0.88 miles one way)

Time for one round trip	=	20 minutes
average speed	=	5.28 mph
Total time to consume six gallons of fuel	=	49 minutes
average consumption	=	7.35 gph
Number of trips (round trip)	=	2-3/4
Number of miles traveled	=	4.85 miles
Time to run out 45 gallons (projected)	=	6.2 hours
Distance to run out 45 gallons (projected)	=	36.5 miles

TESTED BY: C. G. Wells

APPENDIX I - OPERATION LOG

During the test program, a log of operating hours and mode of operation was kept. The log is enclosed with this appendix.

The time period covered by the log is 2 January 1963 to 21 June 1963. The period from 2 January to 8 February consisted of water and snow testing prior to the beginning of the 100-hour endurance testing. Prior to the 100-hour test, the vehicle had acquired 11 hours and 20 minutes of water testing and 4 hours and 50 minutes of snow testing. Some hard-surface testing was also accomplished, but was of insignificant time to be entered in the log. At the end of the test period, a total of 106 hours and 7 minutes of endurance testing and an over-all test time of 122 hours and 17 minutes was acquired. A Servis Recorder was used during the endurance test to log operating time.

It can be seen that the total hours on any one day did not equal eight (a normal working day). This was due to many circumstances; a few of them are listed:

(1) Preparation of vehicle.

(2) Traveling to test site.

(3) Preparation of test site.

(4) Refueling

(5) Intermittent vehicle inspections.

(6) Weather conditions.

(7) Traveling from test site.

The time consumed by these operations varied from day to day.

During the endurance test, it was necessary to repair the radiator and replace a rotor seal. The radiator repair was a result of accidental damage and was not considered to be a failure. The left rear rotor shaft seal was blown, due to a high pressure condition which was later corrected by the addition of a pressure relief valve in the oil supply system. The total down time, including the repair of the radiator, repiping of the oil supply system and replacing the rotor shaft seal, did not exceed 20 hours.

OPERATION LOG

DATE	LOCATION	HOURS OF OPERATION									
		WATER	SWAMP	SAND	EARTH BANK	MARSH	LAND	DITCHES	SNOW	ENDURANCE	TOTAL
	GOAL	30:00	20:00	10:00	5:00	20:00	5:00	10:00			
1-2-63	Detroit River	1:00									1:00
1-3-63	Detroit River	3:00									4:00
1-10-63	Detroit River	2:15									6:15
1-14-63	Chelsea								0:20		6:35
1-15-63	Chelsea								1:15		7:50
1-24-63	Allegan								3:15		11:05
2-5-63	New Orleans	2:30									13:35
2-6-63	New Orleans	2:00									15:35
2-7-63	New Orleans	0:35									16:10
2-8-63	Beginning of official 100 hour endurance testing										
2-8-63	Lee's Island	1:00	0:50							1:50	18:00
2-13-63	Lee's Island	2:10	2:10							5:10	21:20
2-14-63	Lee's Island	1:00	1:35							7:45	23:55
2-18-63	Lee's Island	0:20	0:25							8:30	24:40
2-19-63	Lee's Island	0:25	0:40							9:35	25:45
2-20-63	Lee's Island		0:20					0:30		10:25	26:35
2-21-63	Dauphin Island			2:00						12:25	28:35
2-22-63	Dauphin Island			2:30						14:55	31:05
2-25-63	Dauphin Island			2:42						17:37	33:47
2-26-63	Dauphin Island			4:35						22:12	38:22
2-27-63	Lee's Island	0:20								22:32	38:42
2-28-63	Lee's Island	1:00	2:00			1:40				27:12	43:22
3-1-63	Lee's Island	2:05	1:00		1:00					31:17	47:27
3-5-63	Lee's Island	1:20	2:00		0:30	2:10		0:20		37:37	53:47
3-6-63	Lee's Island	0:30	2:30		1:00	2:00		0:30		44:07	60:17
3-7-63	Lee's Island	0:25	2:00		0:30	2:00		0:30		49:32	65:42
3-8-63	Lee's Island	1:00	3:00		0:10	3:00				56:42	72:52
3-9-63	Lee's Island	1:05	1:00		0:30	4:00		0:30		63:47	79:57
3-11-63	Lee's Island	1:45	1:00		0:10	2:00	1:00	0:30		70:12	86:22
3-12-63	Lee's Island	0:30				4:00	0:25	0:30		75:37	91:47
3-13-63	Lee's Island	4:10			0:10		1:00	1:10		82:07	98:17
3-14-63	Lee's Island	1:50			0:30					84:27	100:37
3-15-63	Lee's Island	1:00			1:00		1:00			87:27	103:37

Cont'd

OPERATION LOG

DATE	LOCATION	HOURS OF OPERATION: WATER	MUCK	SAND	EARTH BANK	MARSH	LAND	DITCHES	SNOW	ENDURANCE	TOTAL
5-8-63	15 Mi. Rd.	1:00					0:15			88:42	104:52
5-9-63	15 Mi. Rd.	4:00					0:20			93:02	109:12
5-10-63	Auburn Hts.	0:30					0:30			94:02	110:12
5-14-63	Auburn Hts.	0:40	0:30							95:12	111:22
5-15-63	Auburn Hts.	0:30	0:30							96:12	112:22
5-17-63	Auburn Hts.	0:25	0:20				0:10			97:07	113:17
5-31-63	15 Mi. Rd.	2:15								99:22	115:32
6-14-63	15 Mi. Rd.	1:00	0:10				0:10			100:42	116:52
6-20-63	15 Mi. Rd.	0:25					0:30	1:20		101:57	118:07
6-21-63	Detroit River	4:10								106:07	122:17
	Sub Total	34:50	22:00	11:47	5:30	20:50	5:20	5:50	0	106:07	
	Total	45:10	22:00	11:47	5:30	20:50	5:20	5:50	5:50		122:17

APPENDIX J - VEHICLE IMPROVEMENTS

A conference was held on 10 May 1963 with Messrs. Ralph Alexander and Noel Bleich of the Bureau of Ships, Washington, D. C.; Lt. Col. Piehl of the U.S.M.C.; Messrs. Grant Beilfuss and Peter Posler of the R S S Ships, Kalamazoo, Michigan; and Messrs. R. Swenson and M. J. Neumeyer of Chrysler Corporation.

Several modifications were suggested during the course of this meeting. These suggested modifications and the action taken are as follows:

ITEM 1: Replace Heli-coil inserts with solid inserts on final drive covers.

ACTION TAKEN: Solid inserts by Rosan have been installed on first vehicle and are going into the second.

ITEM 2: Check for adequate cooling for 115 degree ambient temperature.

ACTION TAKEN: Cooling was checked and found to be marginal without engine cover. Refer to Item 17 following.

ITEM 3: Shroud radiator completely.

ACTION TAKEN: Radiator shroud has been designed and installed on first vehicle and will go on the second vehicle.

ITEM 4: Repair welds and balance rotors dynamically.

ACTION TAKEN: Rotors repaired and dynamically balanced on first vehicle. Dynamic balancing specifications have been set up for second vehicle's rotors.

ITEM 5: Replace plastic oil lines to front rotor bearings with steel lines.

ACTION TAKEN: Steel lines have been installed. Second vehicle is to get steel lines also.

ITEM 6: Replace broken needle bearings and mating parts on left final drive idler shaft. (No. 1 Vehicle only.)

ACTION TAKEN: New needle bearings, idler shaft, and thrust washers were installed. No other replacement of parts was necessary.

ITEM 7: Round end of the rotor blades to reduce "slap" as noticed during high speed runs.

ACTION TAKEN: Front and rear ends of helices were rounded off to reduce "slap" in water.

ITEM 8: Obtain test data of pilot vehicle to compare with model data for predicting performance of possible changes. Also determine C. G. by weighing.

ACTION TAKEN: Data was obtained on performance and is given in the appendix. Vehicle C.G. is given on Characteristics Sheet, Figure I-4, Calculations are given in Appendix L.

ITEM 9: Extend shroud to vehicle width and try. If gain 1/2 mph or more is achieved, retain shroud. If not, Chrysler to make recommendations if to retain or not. If shroud is retained, hand rails will be eliminated.

ACTION TAKEN: Shrouding was installed and tested. Results showed no gain in vehicle speed (refer to Appendix C).

ITEM 10: Chrysler to obtain data on helicopter lift methods and notify bureau as to recommending addition of this feature.

ACTION TAKEN: The Bu Ships have supplied the necessary data on helicopter lifting methods. Minor structural modifications will be made to the second vehicle to effect this requirement.

ITEM 11: Rear Seat:

(a) Install seat backs to height of vehicle sides.

(b) Raise seat 4-1/2 inches.

(c) Provide seat pads.

(d) Install seat belts.

(e) Extend seat as far forward as possible.

ACTION TAKEN: All of the above seat modifications have been complied with.

ITEM 12: Front Seat:

(a) Make driver's seat adjustable.

(b) Provide seat backs

(c) Provide seat pads

(d) Maintain present relative height

ACTION TAKEN: Front seat modifications are being completed in accord with the above requirement. Seat in first vehicle is slightly higher because of the addition of padding.

ITEM 13: Improve Steering Control:

(a) Provide wheel with self centering device

(b) Try adding resistance to rheostat circuit and determine if improvement.

ACTION TAKEN: A self centering spring was designed and installed. Variable resistance was added to the clutch circuit and results were favorable for water performance. Refer to Appendix M.

ITEM 14: Gas Pedal and Foot Brake:

(a) Locate with respect to new adjustable seat

(b) Improve linkage

ACTION TAKEN: Throttle location was improved and a new throttle linkage was designed and installed.

ITEM 15: Hand Throttle:

(a) Add a hand throttle to throttle system, without overide.

ACTION TAKEN: A hand throttle was designed and installed in the first vehicle and will go into the second vehicle.

ITEM 16: Labels:

(a) Label switches, etc.with metal or plastic tags that are screwed on.

ACTION TAKEN: Plastic identification labels have been attached to the dash for instrument and control identification.

ITEM 17: Engine Cover:

(a) Add engine cover if determined to be necessary from engine cooling standpoint.

(b) If protection from hot surfaces is necessary and cover is not required for cooling, use wire mesh.

ACTION TAKEN: An engine cover was considered necessary and was designed and will appear on both vehicles. Improved air handling and protection from hot surfaces is afforded.

ITEM 18: Carbon Monoxide

(a) Investigate CO level in all areas of passenger occupancy.

ACTION TAKEN: Carbon monoxide test has been conducted and results are given in Appendix K.

ITEM 19: Kick-down Linkage:

(a) Bend linkage rod for smaller envelope

ACTION TAKEN: The addition of an engine cover has eliminated the necessity or desirability of this change and it was not made.

ITEM 20: Fire Extinguisher:

(a) Provide bracket for 5 pound CO_2 bottle.

ACTION TAKEN: Brackets for 5-pound CO_2 bottles were procured and will be installed in both vehicles.

ITEM 21: Engine:

(a) Metal plugs should be used for blocking the heater hose connections in the water pump.

ACTION TAKEN: The crimped hose was replaced by suitable commercial plugs.

ITEM 22: Muffler:

(a) Smaller muffler screen - reduce from 10 inches to 8 inches

(b) Screen tail pipe for entire length, 3-inch diameter.

ACTION TAKEN: Muffler and tail pipe screen have been designed and will be placed on both exhaust systems as specified above.

ITEM 23: Air Cleaner:

(a) Use automative dry type air cleaner in lieu of industrial truck type.

ACTION TAKEN: A Chrysler 300-J Air Cleaner will be used on each vehicle. Design adaptation is complete.

ITEM 24: Manuals:

(a) Bring manual up to date with inserts.

ACTION TAKEN: This work is in progress and will be provided with the vehicles.

APPENDIX K - MEASUREMENT OF CARBON MONOXIDE CONCENTRATION

Since the prototype vehicle has an exposed engine and the exhaust system is near the crew, some question is raised as to whether the carbon monoxide concentration is dangerous. Figure K-1 is a National Bureau of Standards Illustration on the length of exposure to CO and the per cent of CO required to cause various effects on humans.

The condition selected as a possible worst case was:

Vehicle stationary

No wind

Engine operating at 1000 rpm

The engine speed was chosen to produce a sufficient quantity of exhaust gas without a high cooling fan speed which would cause excessive air circulation in the area.

The CO concentration was measured with a Mine Safety Appliances Carbon Monoxide Indicator Type 43823. The instrument was charged with fresh chemicals prior to the test and allowed to stabilize in fresh air. Then the probe was located in various areas of the vehicle while measuring CO in per cent. All the areas investigated showed no more than 0.008 per cent concentration which was recorded near the engine. In the crew areas, the greatest concentration was 0.003 per cent. This concentration is considered negligible as it is well below the "perceptable effect" region on the curve. The data acquired is shown on Data Sheet K-1.

1925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 7-3-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Carbon monoxide measurements with Mine Safety Appliance CO Indicator Type 43823

Location	CO Concentration In Percent
10 inches from muffler	.008%
Left rear seat at center	.002%
Right rear seat at center	.003%
At steering wheel	.002%
Directly over intake manifold	.008%

Note: Engine operating at 1000 rpm
Transmission in "N"
Vehicle stationary in still air

TESTED BY: C. G. Wells

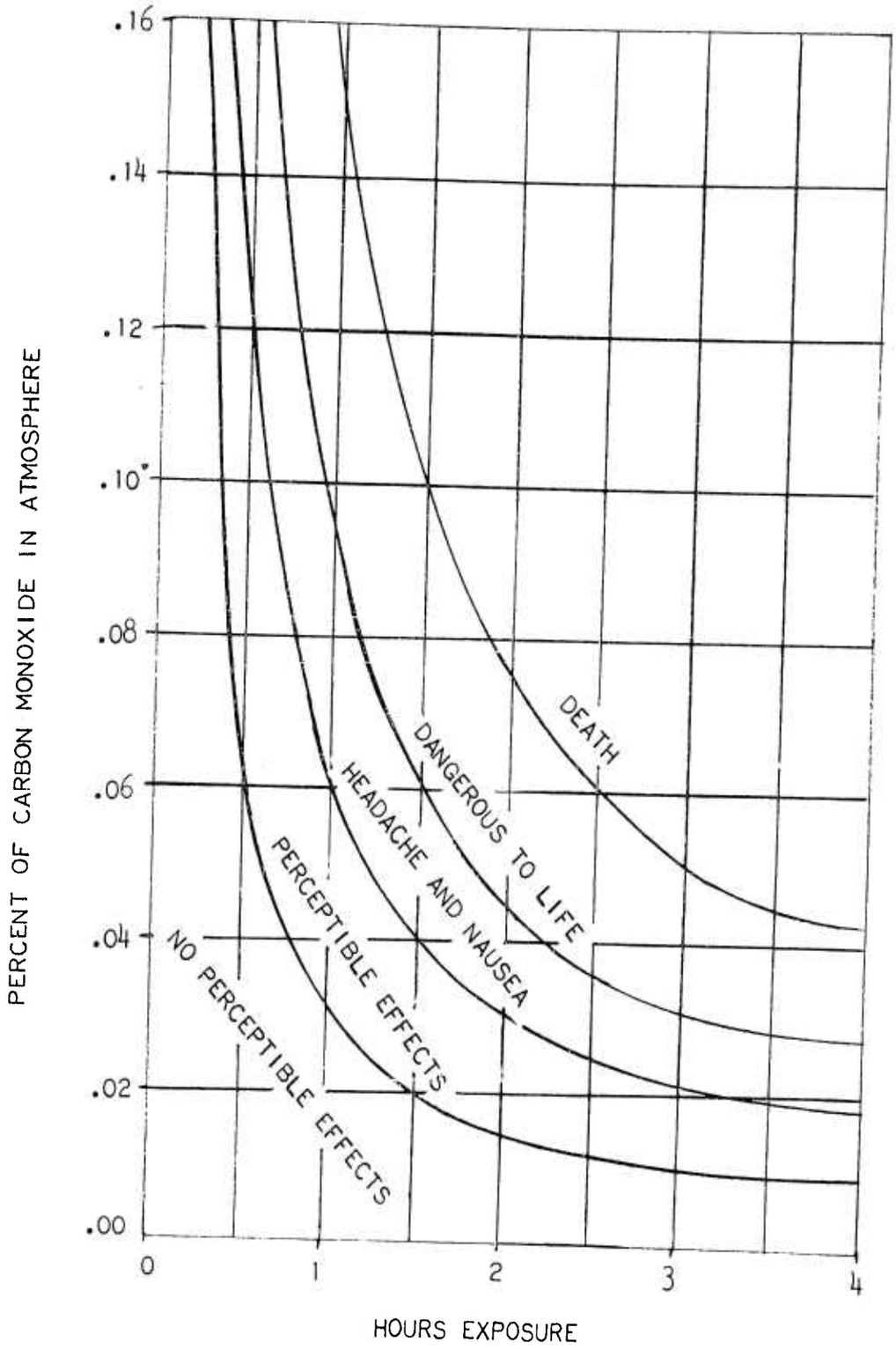


Figure K-1 Effects of Carbon Monoxide for a Given Time on Human Beings (Data from Bureau of Standards Technical Paper 212)

APPENDIX L - DETERMINATION OF CENTER OF GRAVITY

The center of gravity of the vehicle unloaded was determined by the reaction method. Forces were measured at convenient points and moments taken about the reaction points.

The measurements were made with a 5000 pound Baldwin Lima Hamilton Load Cell type U and an SR4 Strain Indicator. The total wet weight of the vehicle was found to be 2445 pounds. Then the load cell was connected to the grab rail at the side of the vehicle approximately in the plane of the center of gravity. The vehicle was raised slightly at the instrumented side and the load measured. The distance between the point of contact with the floor and a vertical line projected down through the grab rail was also measured. The forces were recorded on Data Sheet L-1 and the distance calculated as shown in Figure L-1. The test was repeated on the other side in the same plane to check the results of the first test. The center of gravity was located 4.50 inches off center to the driver's left side. The instrumentation was moved to the front lifting eye and the reaction point to the rear lifting eye. The force and distance measurement was made and the situation was reversed. A new set of measurements was made and the data was entered on Data Sheet L-1 and calculated as shown in Figure L-2. The calculations placed the center of gravity at 44.7 inches ahead of the rear lifting eye.

No attempt was made at this time to locate the center of gravity in the vertical plane. All the tests were run with the vehicle unloaded, no fuel, but with oil in the engine, transmission, etc. and water in the radiator. The vehicle configuration was according to the unmodified design status.

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 7-3-63

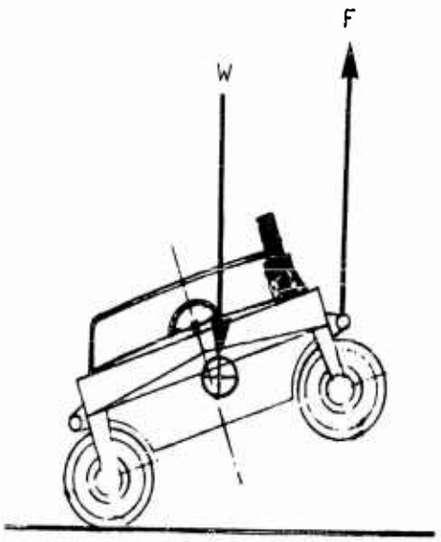
PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Center of Gravity Test Data

Test	Load Indicator Reading		Difference		Load in Pounds	
No load	10	1042				
Total Weight	12	998	19	56	24	45
No Load	10	1018				
Drivers Left Up	10	1975	9	57	11	97
No Load	10	1018				
Drivers Right Up	10	1889	8	71	10	90
No Load	10	1018				
Front Up	10	1700	6	82	8	53
No Load	10	1018				
Rear Up	12	0290	12	72	15	92

TESTED BY: C. G. Wells



TOTAL WT = 2445 LB

F = 1197 LB

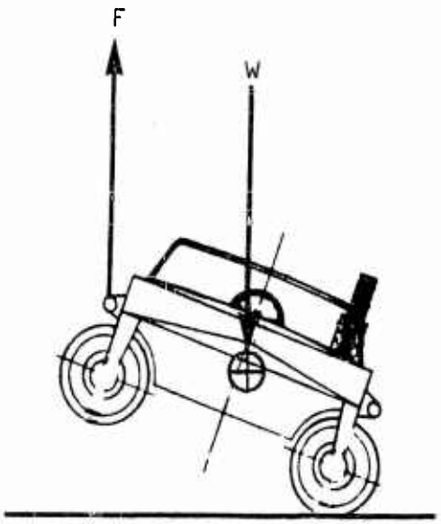
$\bar{X}$ W = L'F

$\bar{X} = \frac{L'F}{W} = \frac{69.38 \text{ IN} \times 1197 \text{ LB}}{2445 \text{ LB}}$

= 33.95 IN

69.38 IN

(ADD .5 IN TO ACCOUNT FOR ANGLE OF VEHICLE IN RAISED POSITION)



$\bar{X}_C$ = 34.45 IN

$\bar{X}$XXX $\bar{X}' = \frac{L'F}{W}$

F = 1090 LB

$= \frac{69.38 \text{ IN.} \times 1090 \text{ LB}}{2445 \text{ LB}}$

69.38 IN.

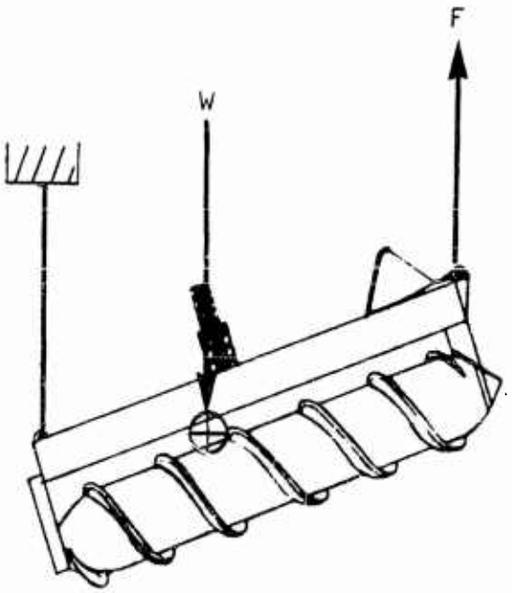
$\bar{X}'_C$ = 30.95 IN.
$\bar{X}'_C$ = 34.45 IN.

THE CENTER OF GRAVITY IS:

34.45 IN. FROM THE CENTER OF THE DRIVER'S RIGHT ROTOR

31.45 IN. FROM THE CENTER OF THE DRIVER'S LEFT ROTOR

Figure L-1 Lateral C.G. Calculations



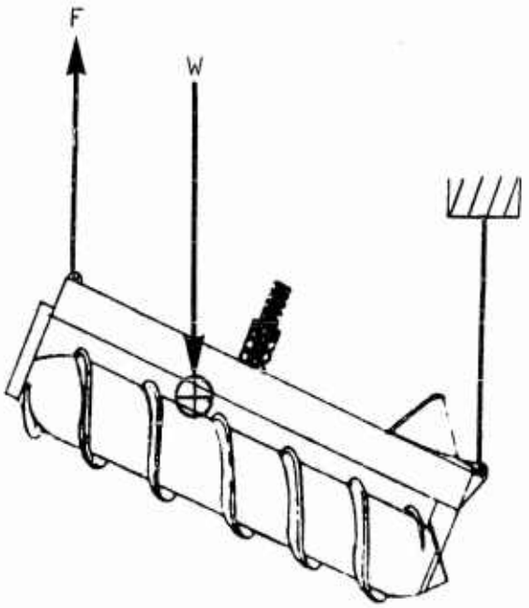
$W = 2445 \text{ LB}$

$F = 853 \text{ LB}$

$L = 128 \text{ IN.}$

$$= \frac{LF}{W} = \frac{128 \text{ IN.} \times 853 \text{ LB}}{2445 \text{ LB.}}$$

$= 44.7 \text{ IN.}$



$F = 1592 \text{ LB}$

$$\bar{Y}' = \frac{128 \text{ IN.} \times 1592 \text{ LB}}{2445 \text{ LB}}$$

$= 83.3 \text{ IN.}$

THE CENTER OF GRAVITY IS:

83.3 IN. TO REAR OF FRONT LIFTING EYE

44.7 IN. TO FRONT OF REAR LIFTING EYE

Figure L-2 Longitudinal C.G. Calculations

APPENDIX M - IMPROVEMENT OF STEERING CONTROL

During the first test series it became apparent that the steering was functioning as designed, but the response was spread over too narrow of a band during water or snow operation; the steering control began to have effect at approximately 90 degrees wheel position and full steer occurred at 110 degrees wheel position. To optimize the steering rate, the design was analyzed, some testing conducted, and an improvement made by addition of more resistance in the steering circuit (See Figure M-1.)

Since steering is accomplished by the interaction of an electrical clutch and brake system, it appeared that an electrical change may improve the condition. The clutch, in order to steer, is permitted to slip resulting in a reduction in speed of one rotor, and the amount of slip determines the turning circle. At some wheel position, the brake is energized which stops the rotor entirely and gives the maximum steer condition. The torque to slip the clutch is determined by the clutch coil current and is the same for all operations, but the torque being carried by the clutch varies with gear range and throttle setting. As a starting point, gear range "2" and wide open throttle conditions were assumed for water operation which results in a transmission output torque at full speed of approximately 250 lb-ft or 125 lb-ft per rotor. (See engine curves in Appendix A) This compares to an output torque of 800 lb-ft during land operation with the transmission in "1" at wide open throttle and the vehicle moving at a slow rate.

In order to evaluate the conditions existing in the vehicle steering circuit prior to making a change, a test was run by measuring clutch and brake current at various wheel positions. The data was plotted on Figure M-2 and is entered on Data Sheet M-1. This plot confirms the observation that steering during water operation occurs between 90 to 110 degrees wheel position. The curve also shows that with the wheel at less than 12 degrees from center, the clutches will transmit at least 720 lb-ft each (1440 lb-ft total). Thus, during land operation, steering control probably extends from 12 degrees to 140 degrees.

In order to evaluate the steering with additional resistance in the circuits, it was decided to put a potentiometer in series with the steering potentiometer, and rerun the previous test at various settings. Calculations based on Ohm's law indicated that a 10 ohm potentiometer would cover the desired range. This unit was installed along with a switch to turn off the brake circuit. (Figure M-3). The clutch coil current required to obtain the desired torque was found by a plot of manufacturers data which is shown on Figure M-4.

The test was rerun while adjusting the series resistance to give 120, 200, 300, and 565 (design) lb-ft slip torque at 20 degrees wheel position. The data was entered on Data Sheet M-1 and is plotted on Figures M-1 and M-4.

After completion of the laboratory tests, the vehicle was tested in the water and the driver was permitted to adjust the external potentiometer to obtain a position that would give the most desirable steering rate. The general opinion of three drivers was that the best steering "feel" occurred with the potentiometer set at 6 to 8 ohms (150 to 200 lb-ft clutch setting). The steering was also evaluated with the brake circuit energized and

de-energized. The opinion of the drivers was that the brake improved steering control and permitted a smaller turning circle. It was noted that the 200 lb-ft setting was not desirable for land operation; therefore, if the added resistance is used it must be switched out during land operation.

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 5-28-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Steering evaluation @12.5 vdc.

Clutch current and torque and brake current and torque

Steering Wheel Position	0 OHMS AMPS	0 OHMS Lb - Ft -		2.7 OHMS AMPS	2.7 OHMS Lb - Ft -		5.0 OHMS AMPS	5.0 OHMS Lb - Ft -		9.1 OHMS AMPS	9.1 OHMS Lb - Ft -
Clutch 0	3.05	720		3.05	720		3.05	720		3.05	720
20	2.39	565		1.25	300		0.84	200		0.42	120
40	1.71	405		0.96	228		0.67	159		0.405	96
60	1.20	284		0.74	175		0.51	121		0.322	74
80	0.74	175		0.45	107		0.32	73		0.217	52
100	0.31	74		0.277	54		0.15	35		0.105	25
120	0.15	35		0.10	24		0.06	14		0.06	14
140	0	0		0	0		0	0		0	0
Brake 80	0	0									
90	0.018	19									
100	0.32	51									
110	0.79	125									
120	1.22	193									
130	1.69	267									
140	2.63	373									
150	3.42	540									

TESTED BY: C. G. Wells

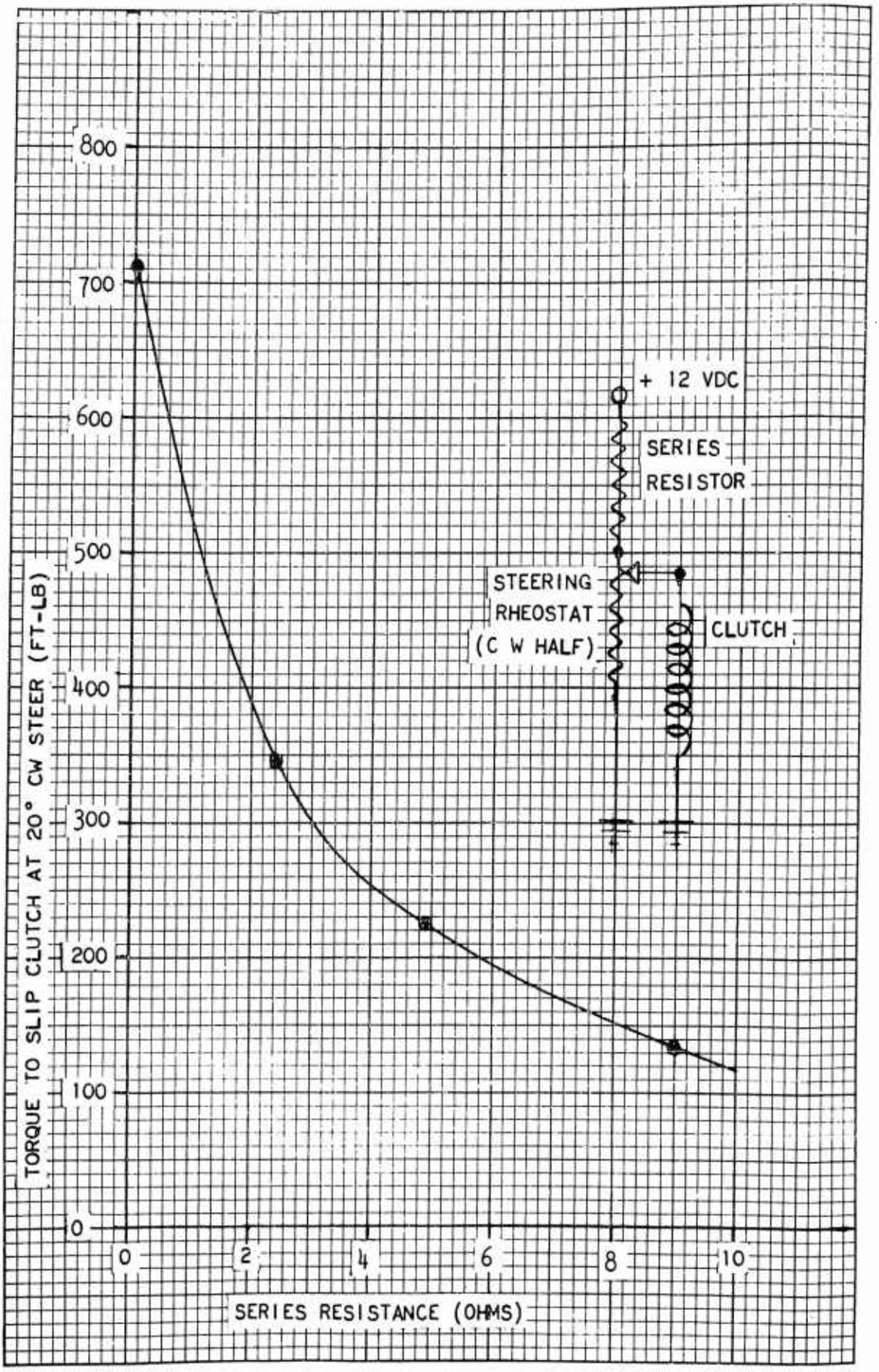


Figure M-1 Effects of Adding a Series Resistance

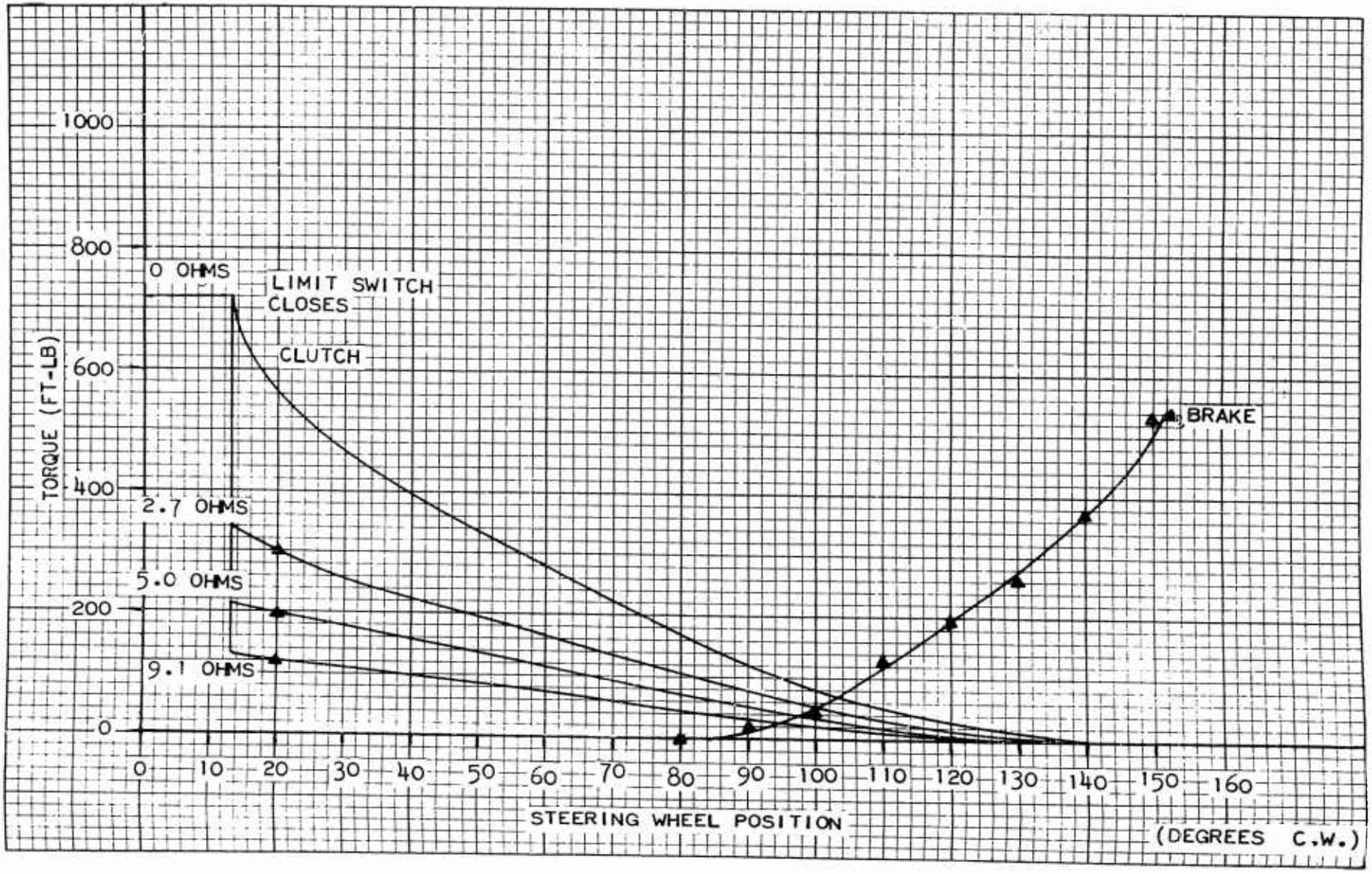


Figure M-2 Effects of Resistance on Steering Control Characteristics

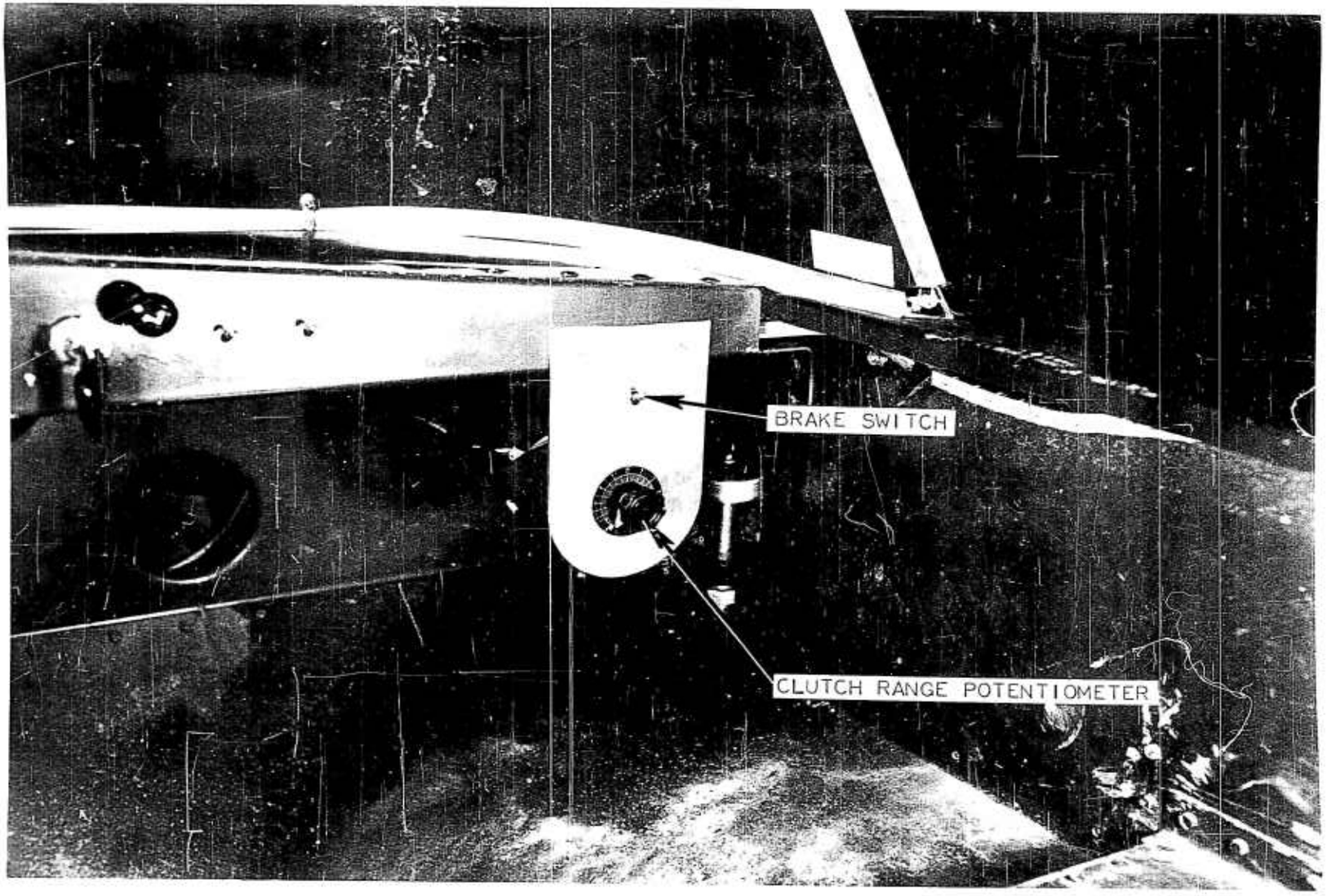


Figure M-3 . Steering Investigation Instrumentation

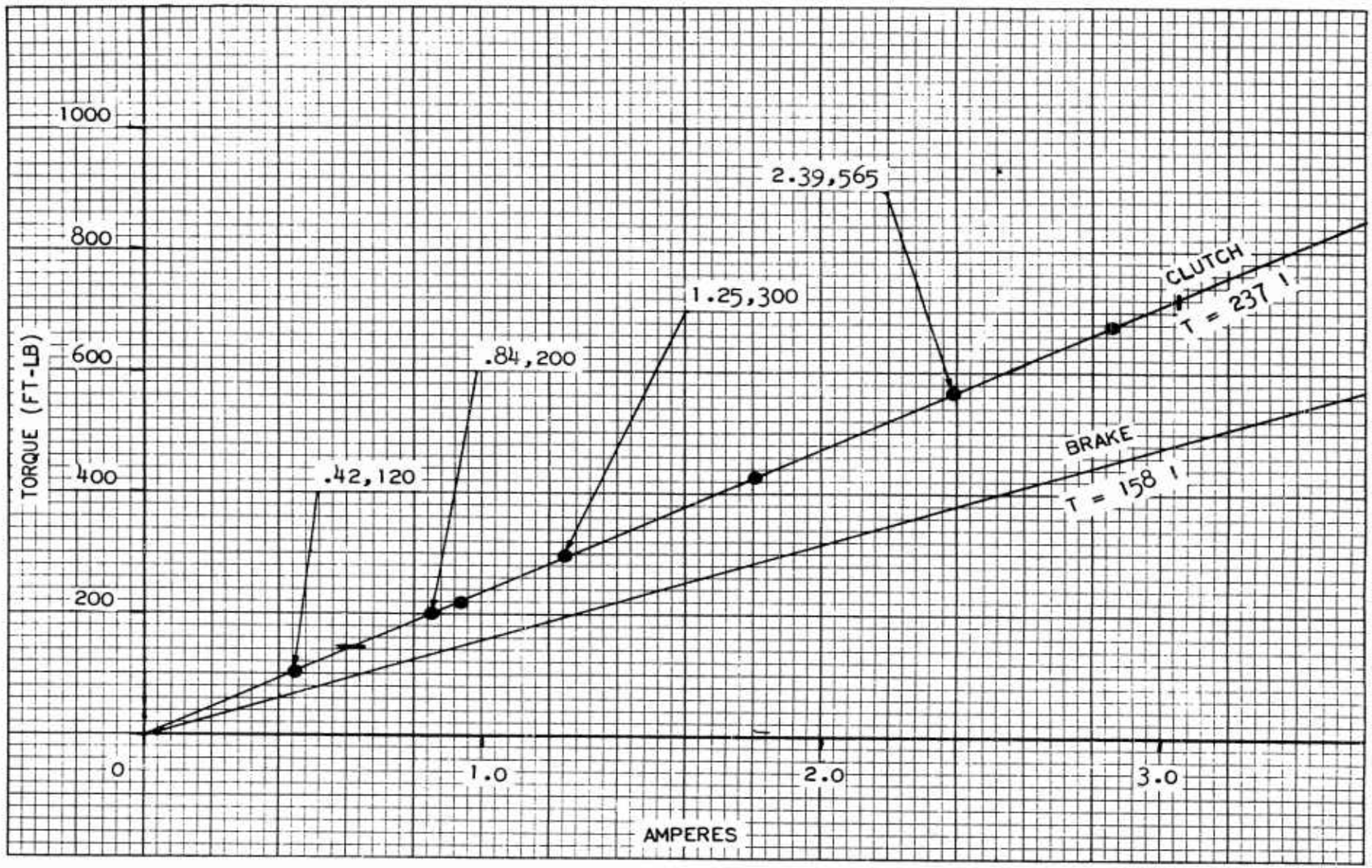


Figure M-4 Current and Torque Relationships

APPENDIX N - DETERMINATION OF EFFECT OF LOAD DISTRIBUTION ON TRIM ANGLE

A series of tests were conducted on 14 March 1963 to determine what effect redistributing the payload would have on the attitude of the vehicle while operating in the water at full speed. For safety purposes, a crew of two men with additional weights to total 1133 pounds or the approximate equivalent of seven passengers was used. Data Sheet N-1 lists the items used and the weight of each.

The first test was run with normal passenger distribution: three in the front and four in the rear. The trim angle with the vehicle stationary in the water was 3.50 degrees bow up attitude. At full speed, the trim angle increased to 4.5 degrees bow up attitude. Next, the weight was shifted to simulate four passengers in front and three in the rear. The trim angle with the vehicle stationary was 1.5 degrees bow up attitude and decreased to 1 degree stern up attitude for a total change of 2.5 degrees. Since the vehicle tended to dip bow down, a full speed test was not run. The final test was run with a passenger distribution of two in the front and five in the rear. This distribution resulted in a 5.5 degrees bow up trim angle at rest and a 12.5 degrees bow up trim angle at full speed. All the tests were run with the transmission in "2." The data required is recorded on Data Sheet N-2. During this test, it was found that the design condition, three passengers in front and four passengers in the rear, is the best of the three configurations tested with respect to vehicle attitude.

1925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 1 DATE 3-14-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Load used during trim testing to simulate passengers

ITEM	WEIGHT IN LBS.
Two men	340
Reserve tank with fuel	50
Fire extinguisher	23
Tool box and tools	10
Shovel, waders, etc.	50
Eleven sand bags	660
Total Payload	1133 lbs
Plus 25 gals. fuel in the main fuel tank	

TESTED BY: M. J. Neumeyer

3925 REV. 4-46

LABORATORY TEST SHEET

TEST NO. 2 DATE 3-14-63

PART TESTED Marsh Screw Amphibian

MODEL 1 SERIAL

REMARKS Trim angle vs loading

Payload 1133 lbs and 25 gals. gas.

Test		Crew Location Front		Rear		Trim at Dock		Trim at Full Speed		Range	Engine RPM
1		3		4		+3½°		+4½°		2	3200 to 3400
2		4		3		+1½°		-1°		2	2400*
3		2		5		+5½°		+12½°		2	3400
	+	Indicates bow up attitude									
	-	Indicates bown down attitude									
	*	This test was not run at full throttle due to the bow down attitude.									
		See Sheet 1 for load weights									

TESTED BY: M. J. Neumeyer

APPENDIX O - TEST SITE IDENTIFICATION AND DATA

In order to determine the vehicle performance and mobility potential of the Marsh Screw Amphibian, it was tested on various types of surfaces. Five test sites were selected in Michigan (Figure O - 1) representing fresh water, swamps, turf, marsh, light snow, and deep snow conditions.

Three locations were chosen in the Mississippi River Delta Region of Louisiana (Figure O - 2) where brackish water, marshy terrain, mud flats, mud banks, tidal streams, and similar features provided surfaces comparable to those found in Southeast Asia. An island off the coast of Alabama supplied the salt water surf environment and sandy beaches to complete the test program.

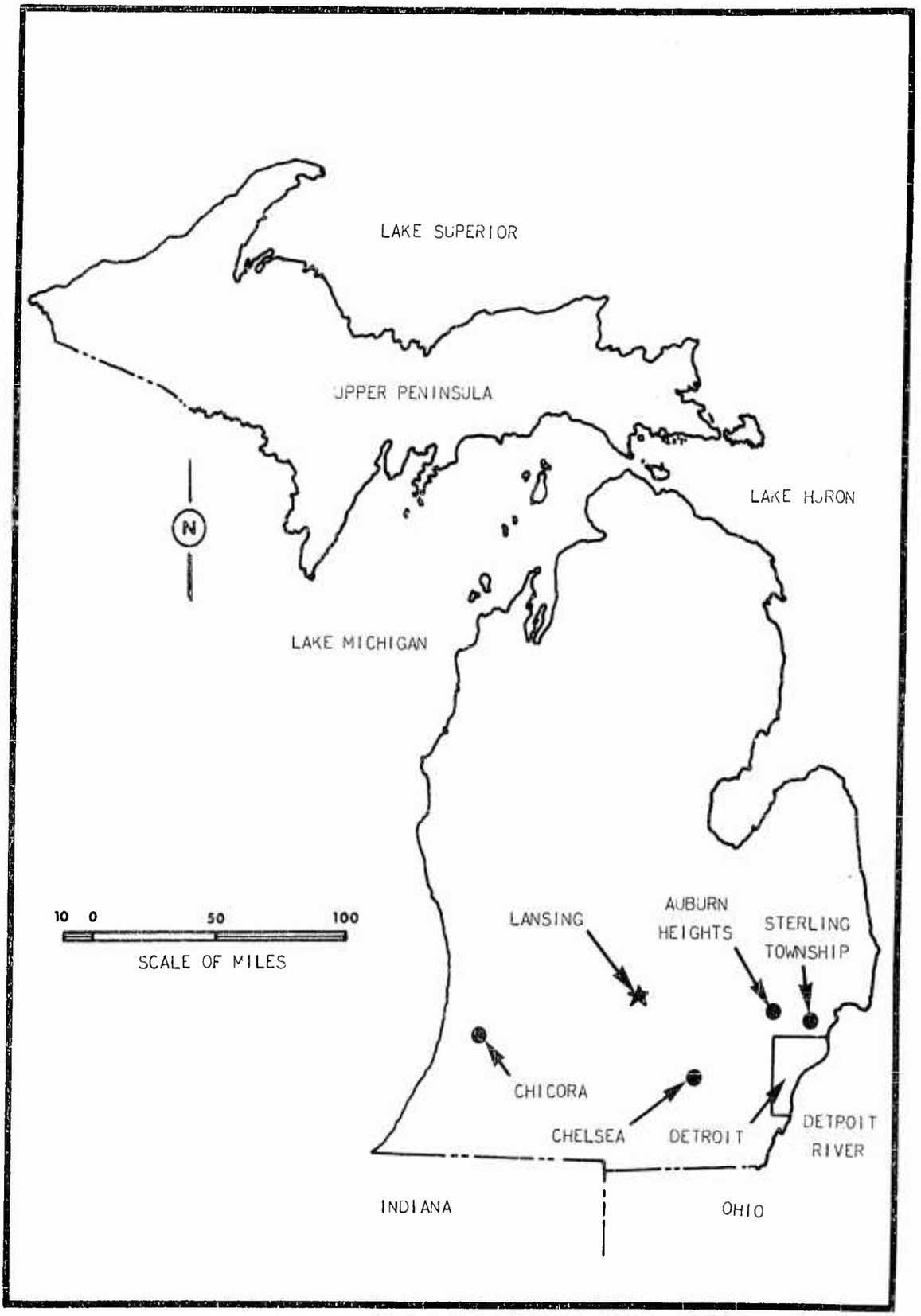


Figure O-1 Location of Test Sites in Michigan

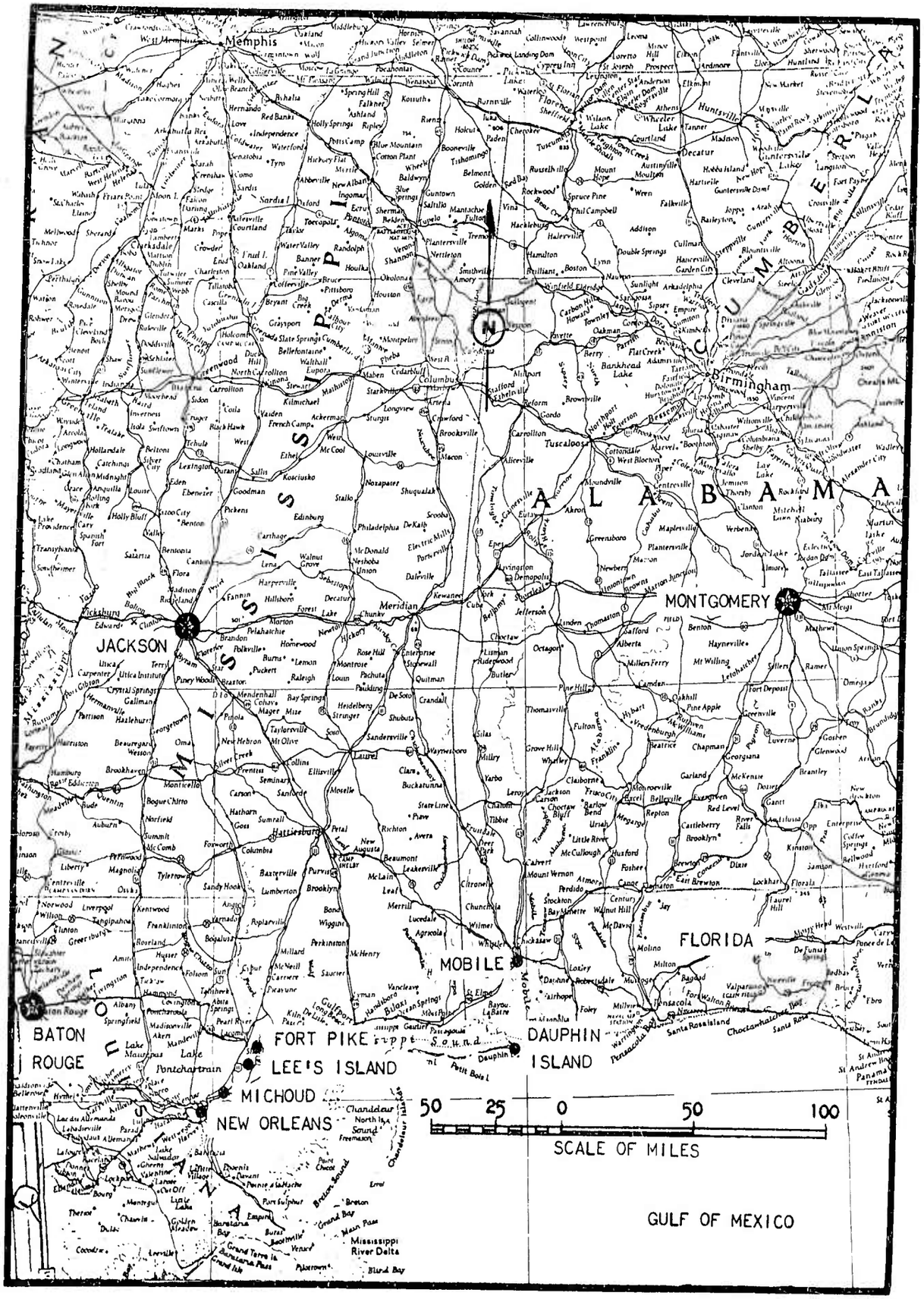


Figure 0-2 Location of Test Sites in Louisiana and Alabama

1. DETROIT RIVER TEST SITE, DETROIT, MICHIGAN

Fuel economy, speed, drawbar pull, and towing resistance tests were run in the Detroit River between Detroit proper and Belle Isle. The fresh water course was in close proximity to the Detroit shoreline and stretched from the Mac Arthur Bridge east - northeastward to a U-shaped boat basin (Figure O - 3) a distance of 0.85 mile. Channel depths along this course reach a minimum of four fathams (24 feet) and, at the time of the tests, the current velocity was measured at 1.5 mph, (Figure O - 4).

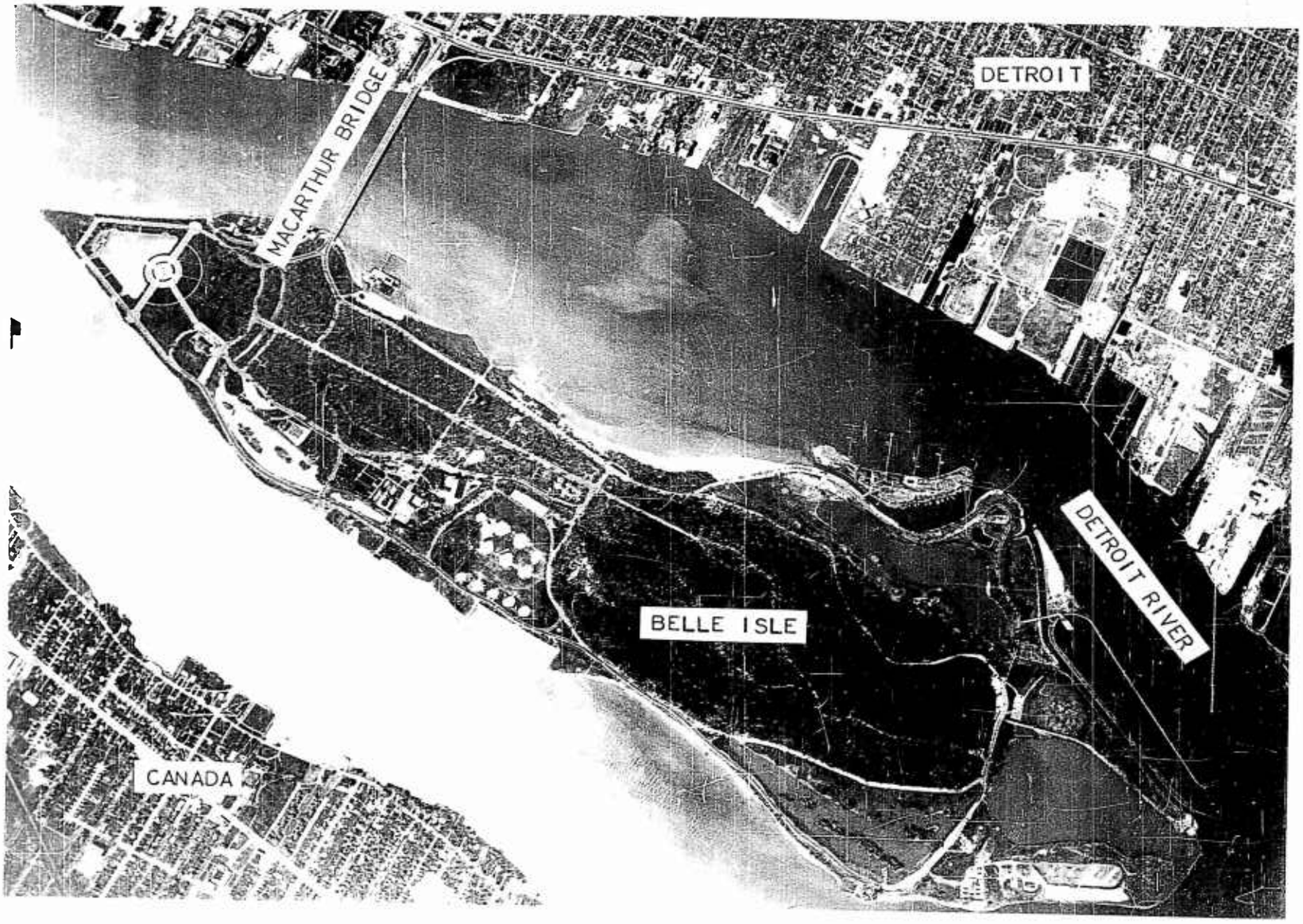


Figure 0-3 Aerial View of Detroit River Test Site

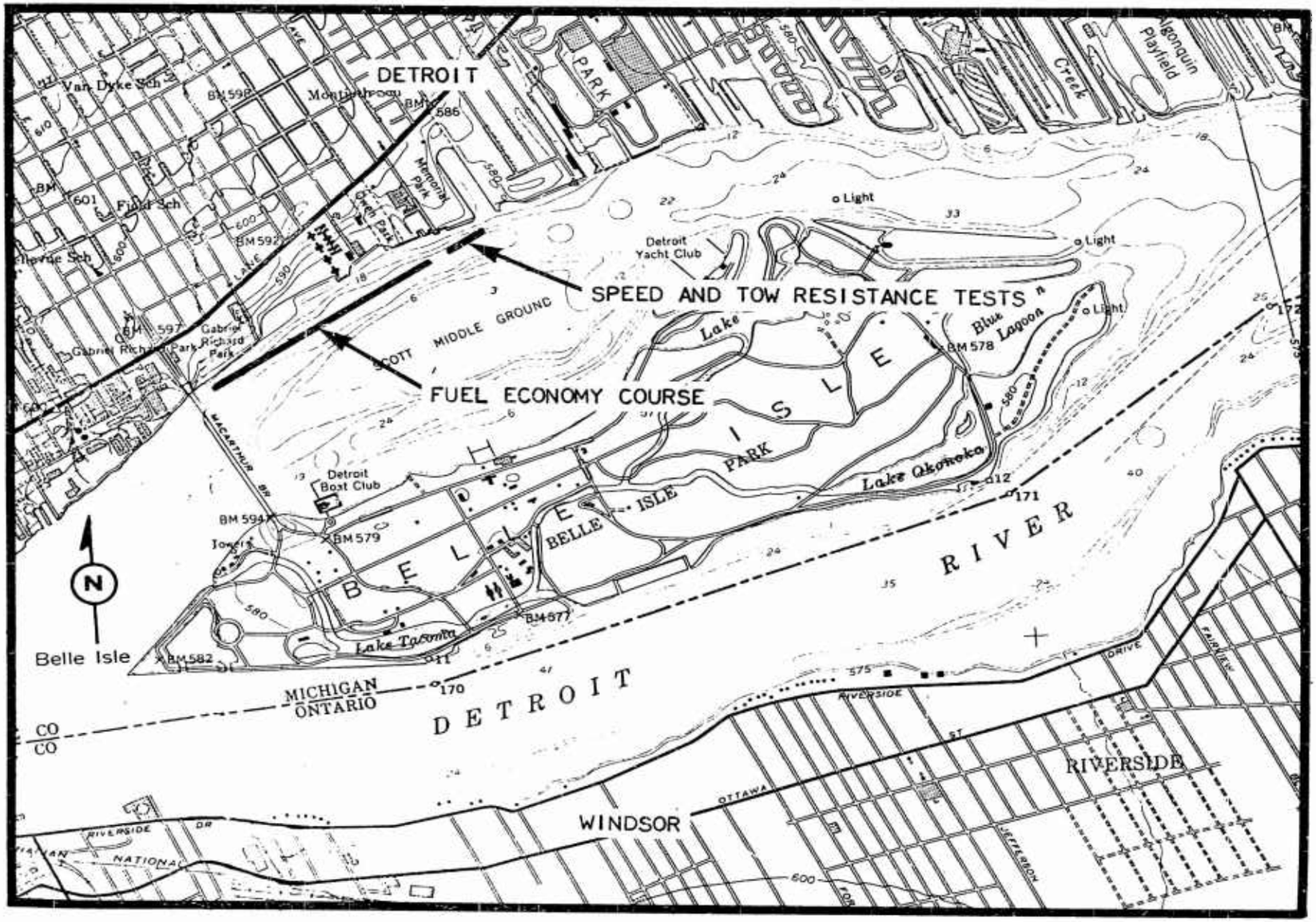


Figure O-4 Topographic Map of Detroit River Test Site

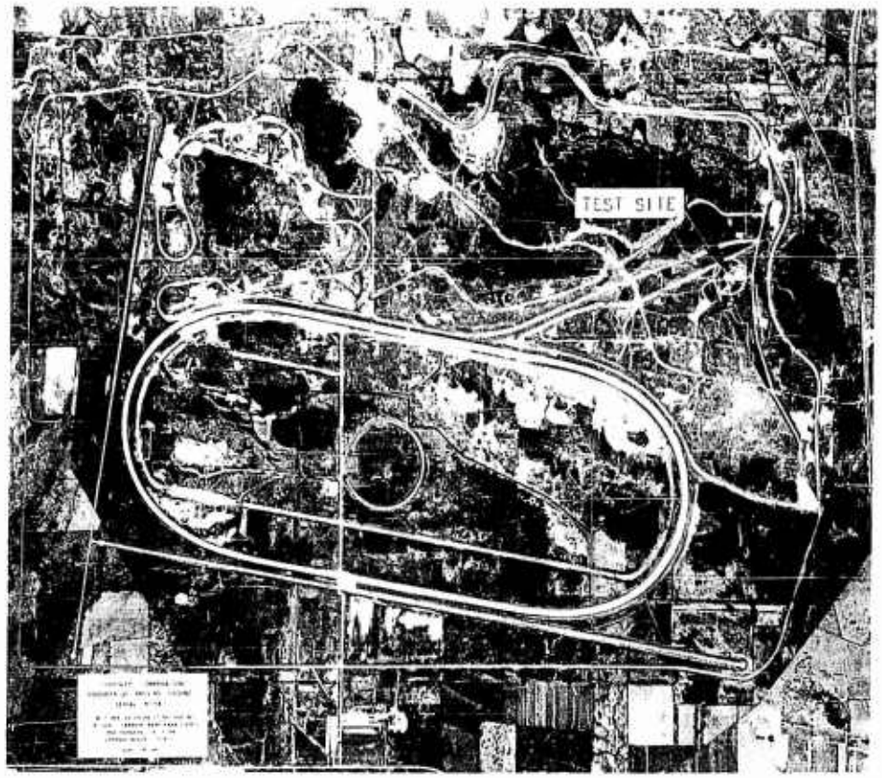
2. CHELSEA TEST SITE, WASHTENAW COUNTY, MICHIGAN

This test site is located within the Chrysler Engineering Proving Grounds in Washtenaw County, Michigan. The 4,000 acre establishment is situated approximately three miles south of Chelsea, 16 miles west of Ann Arbor, and 21 miles east of Jackson. It covers an area roughly three miles long and two miles wide, and ranks as one of the largest proving grounds in the world. (Figure O - 5)

The surface relief ranges from undulating and smoothy rolling to rough and hilly. In places it is choppy, with high knolls, sharp ridges, steep slopes, and rounded depressions. It is stony in places, with large and small stones imbedded in the soil and scattered over the surface. Occasionally, the stones are nested.

The lowest elevation on the proving grounds is 915 feet above sea level, and the highest is 1,070 feet above sea level. (Figure O - 6) In order to make the roads stable and suitable for vehicle testing, it was necessary to dig out many of the swamps and marshes found in the depressions, and then refill them. In some cases it was necessary to go down as far as 18 feet to remove all of the muck before a firm bed was reached.

The surface soils covering the uplands range in texture from fine sand to silt. However, on the days that the Marsh Screw Amphibian was tested here, a layer of snow, varying in thickness from one to six inches, blanketed the surface.



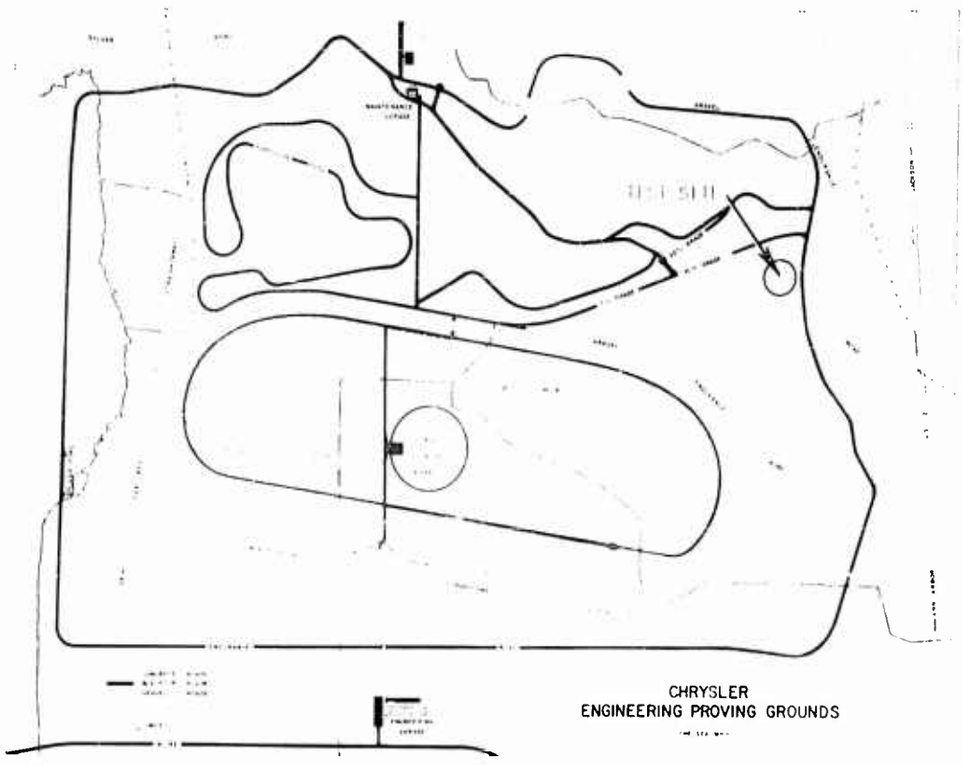


Figure 0-5 Aerial View and Plan of the Chrysler Engineering Proving Grounds

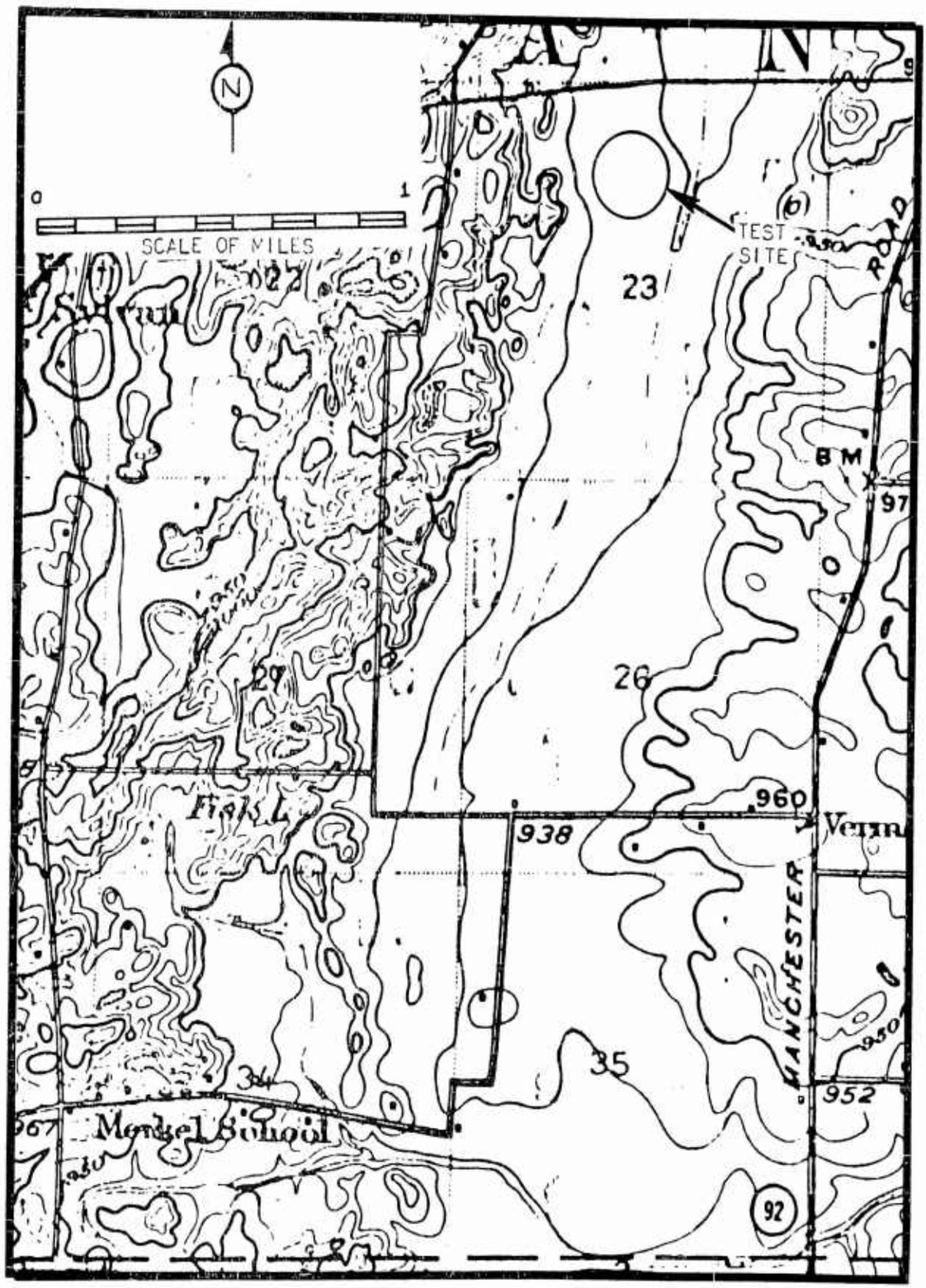


Figure O-6 Topographic Map of Chelsea Test Site

A half-inch thick hard crust had formed on the snow cover because of thawing and refreezing. Daytime temperatures rose to a maximum of 20° F.

The actual test site may be described as having a smoothly rolling surface configuration, and it is located in the north-central section of the proving grounds. Slopes varied from 0 to 30 per cent.

3. CHICORA TEST SITE, ALLEGAN COUNTY, MICHIGAN

This test site is located in an open field immediately east of Chicora, a crossroads hamlet, approximately five miles southwest of Allegan, the County Seat of Allegan County, Michigan. (Figure O - 7) Furthermore, the site lies 23 miles northwest of Kalamazoo and 34 miles south-southwest of Grand Rapids.

The topography in the vicinity of the test site ranges from undulating and gently rolling to rough and hilly. In fact, the terrain and soil types are similar to those found at Chelsea. However, because of its position and proximity to the eastern shore of Lake Michigan, Chicora experiences heavier snowfalls than Chelsea. It is for this reason that the former location was chosen as the site of deep snow tests.

When the Marsh Screw Amphibian arrived at Chicora, a thick snow cover lay on the ground. Snow had been falling for over a week and had accumulated to an average depth of 36 inches. In depressions and around obstructions, the wind had deposited six-foot high drifts. The snow was dry and powdery, somewhat comparable to arctic-type snows. During the test period, temperatures ranged from a low of -20° F at 8:00 a.m. to a high of -5° F at 1:30 p.m. Windblown snow was in the air, being driven by a 20 mph wind.

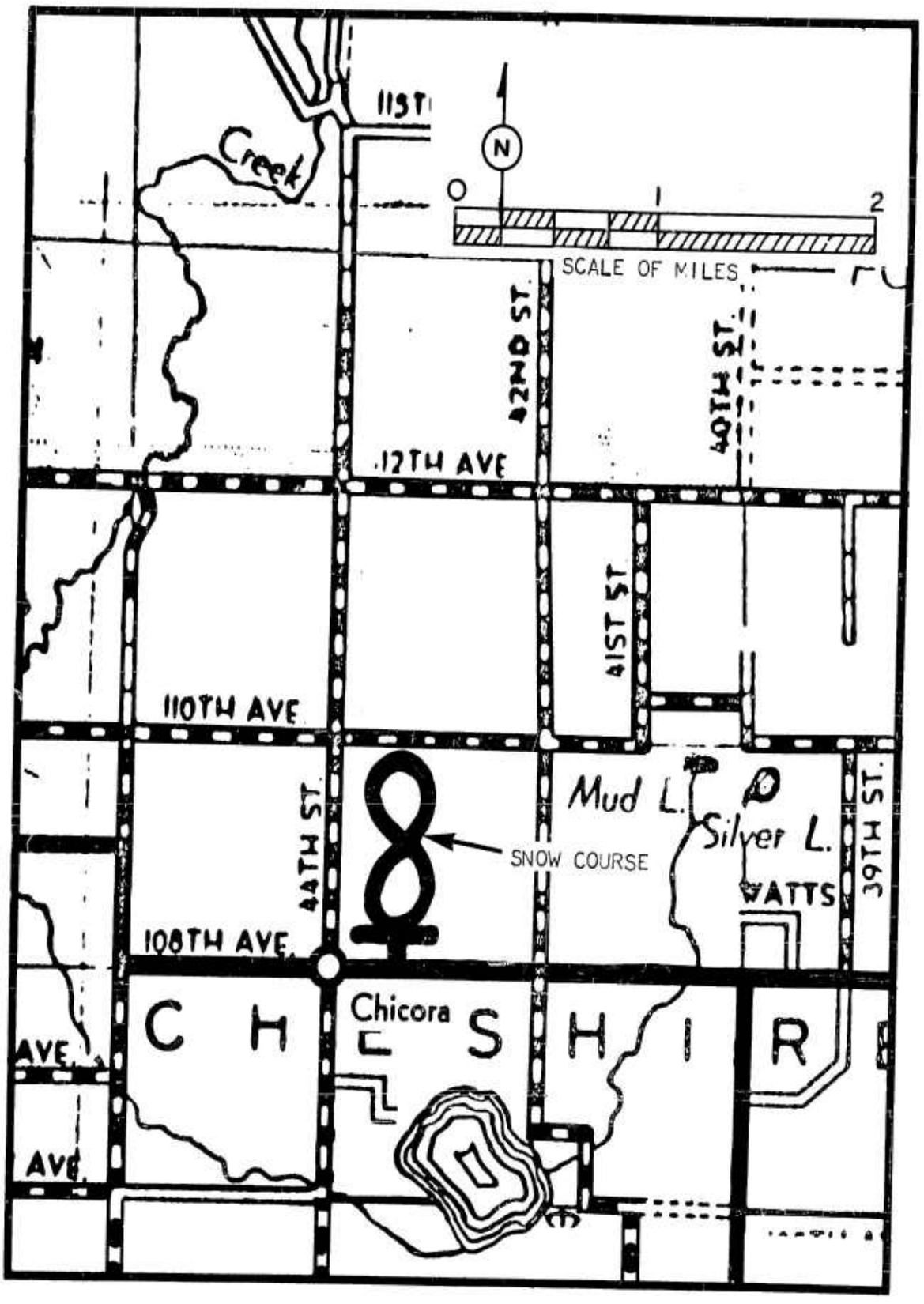


Figure O-7 Chicora Test Site

4. MICHOUD TEST SITE, ORLEANS PARISH, LOUISIANA

The Michoud Canal comprises this test site, located eight miles east of New Orleans in Orleans Parish. The canal lies between U.S. Highway 90 on the north and the Intracoastal Waterway on the south, and serves as an access route between the latter and the NASA Michoud Plant (Figure O - 8).

The canal is 1.75 miles long and 300 feet wide. A deep channel (32 feet) occupies the west side of the canal; whereas, the opposite side is moderately shallow (10 feet.) The land between the levees along both banks of the canal has been raised, with dredgings from the canal, to an average elevation of about five feet. (Figure O-9) No other protection is afforded to this area against flooding from the canal.

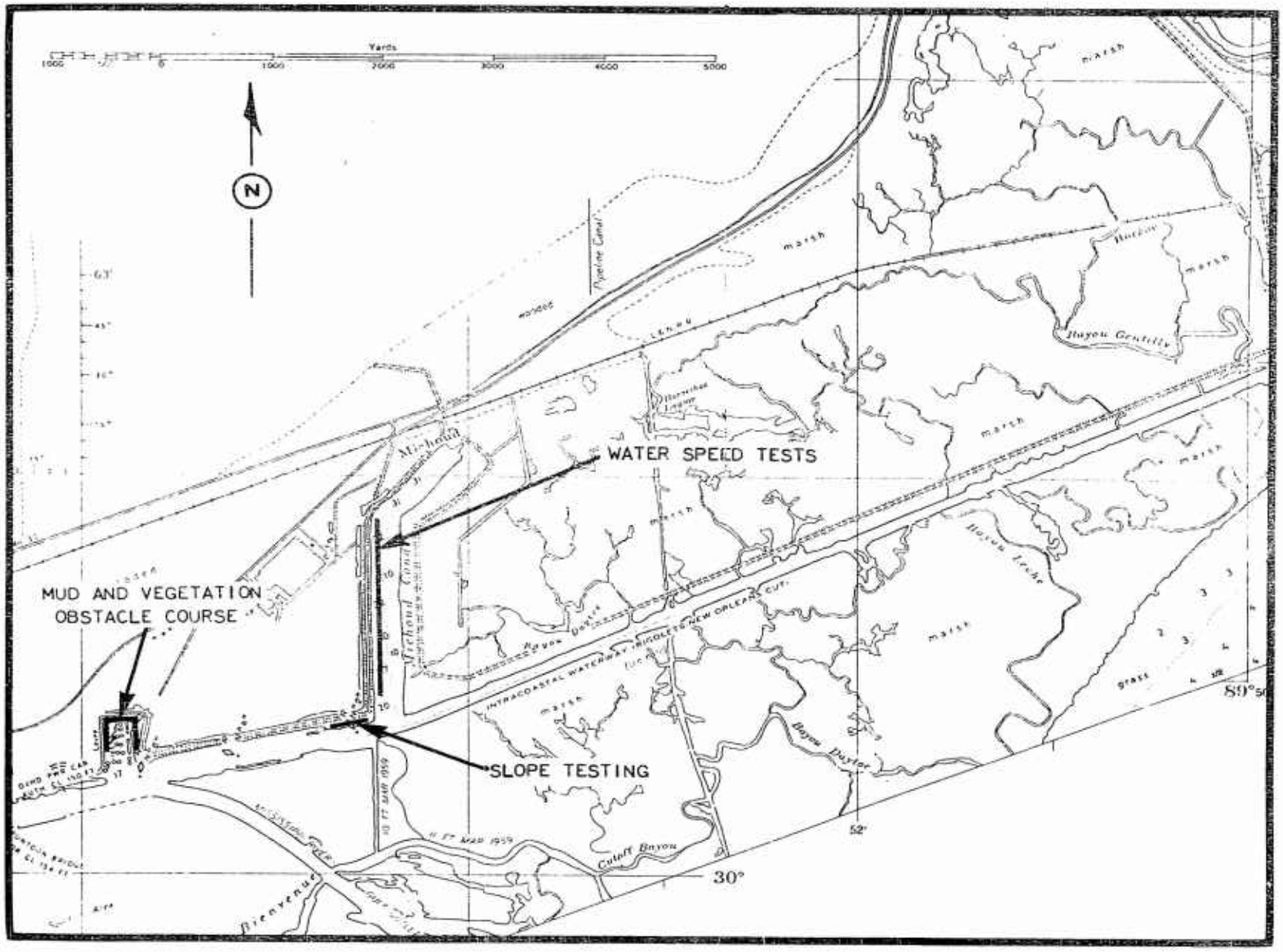


Figure O-8 Hydrographic Chart of Michoud Test Site

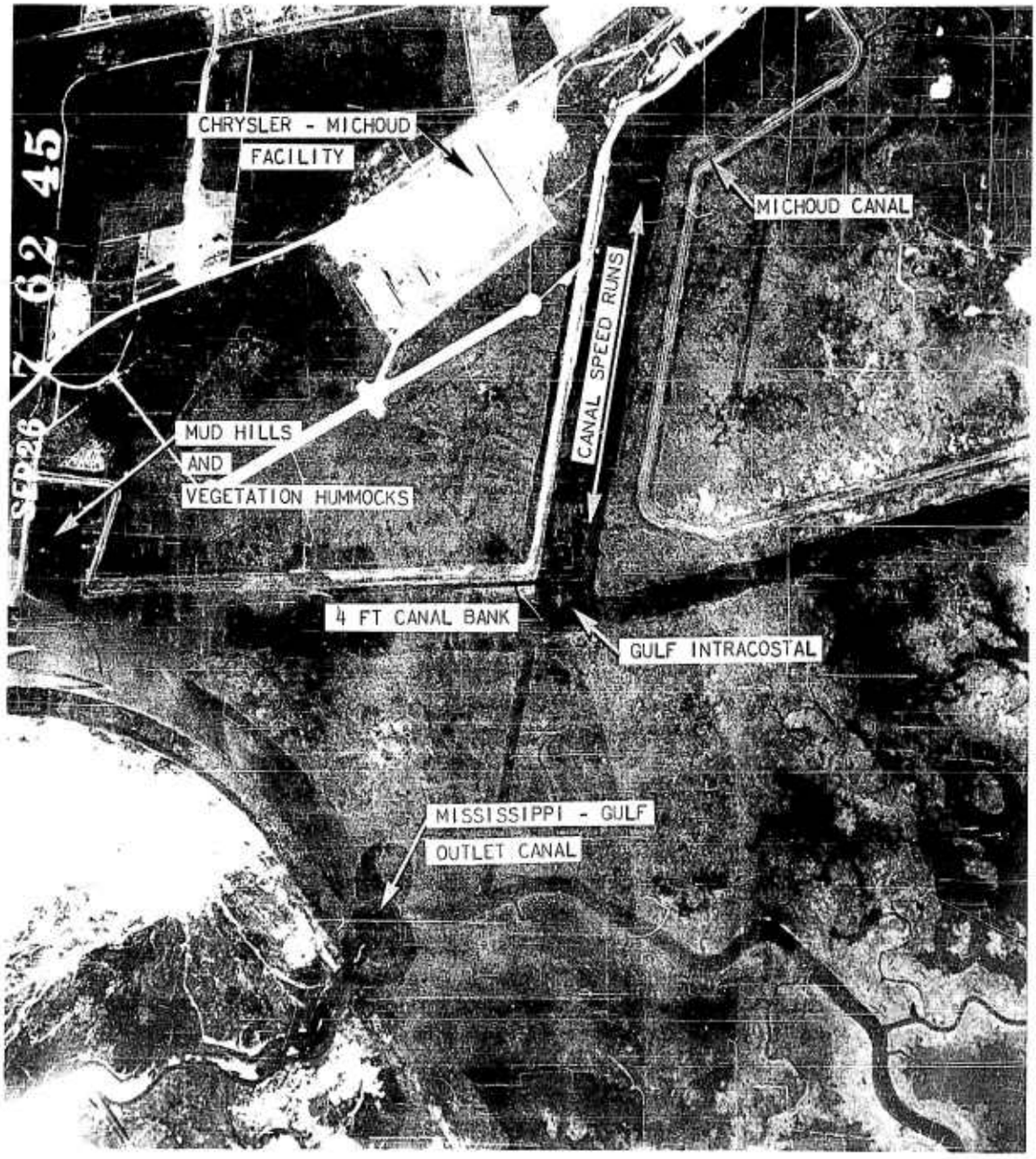


Figure 0-9 Aerial View of Michoud Test Site

5. DAUPHIN ISLAND TEST SITE, MOBILE COUNTY, ALABAMA

Maneuverability in ocean surf and beach mobility tests were conducted along the south shore of Dauphin Island. This island lies about 3.5 miles off the Alabama Coast but is accessible by causeway from Cedar Point. (Figure O - 10) The island is 13 miles long and from a half to one mile wide.

Sand dunes and sandy beaches are found along the south coast where the Marsh Screw Amphibian was tested. They were formed by near shore bottom Gulf material that had been deposited by waves. One-foot wave heights are experienced almost hourly. The median grain size of the beach sand is 0.2 mm, but may range from 0.1 mm to 0.4 mm.

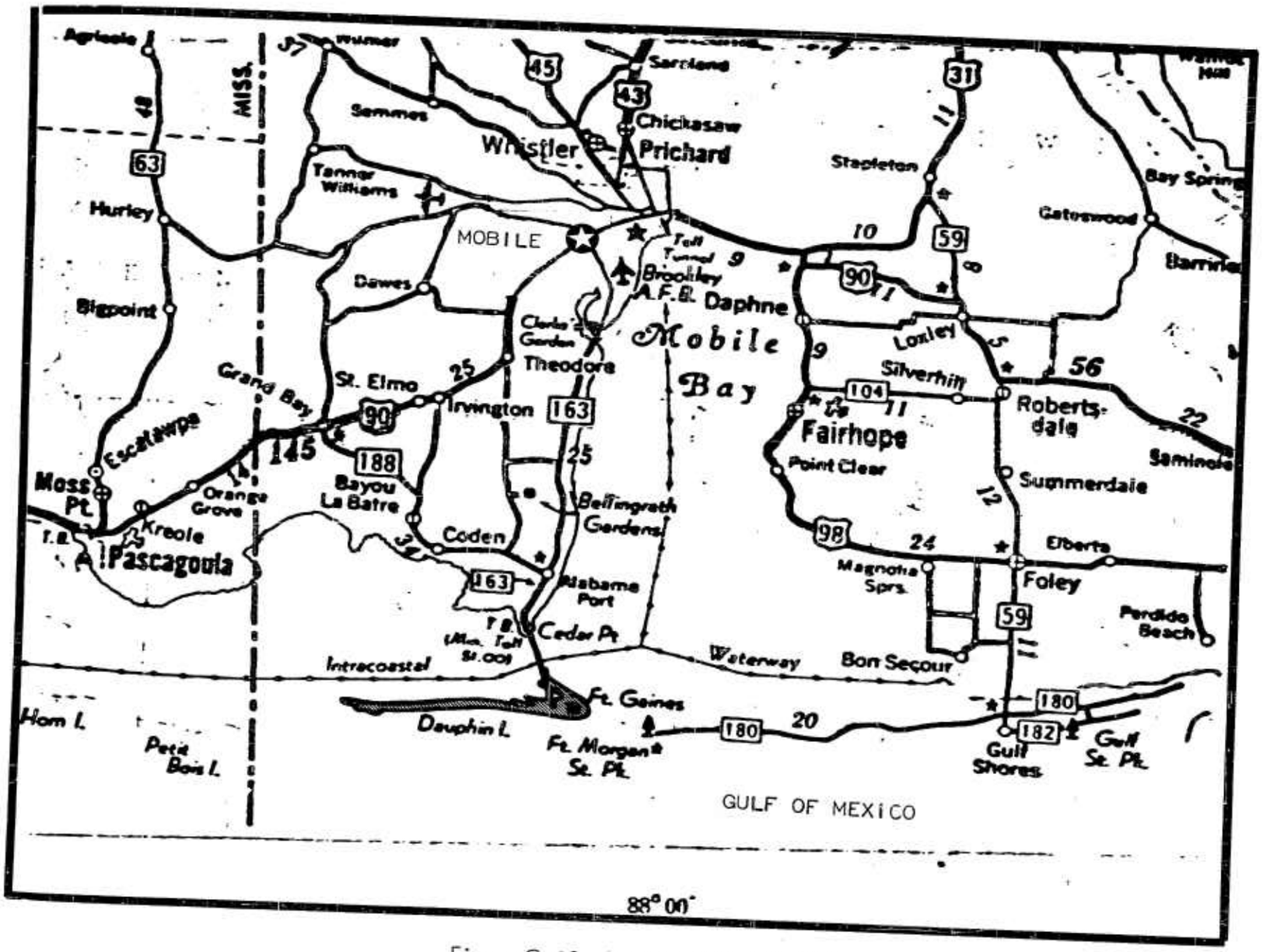


Figure O-10 Dauphin Island Test Site

6. LEE'S ISLAND TEST SITE, ORLEANS PARISH, LOUISIANA

This site is located about 20 miles northeast of New Orleans, in Orleans Parish, and lies off the east coast of a marshy peninsula that separates Lake Pontchartrain and Lake St. Catherine. Lee's Island forms the western shore of Sawmill Pass, which is the northern outlet of Lake St. Catherine. (Figure O - 11).

The island is approximately 1.75 miles in length and averages about one quarter of a mile in width. It is covered by a marshy surfact, which has been classified as a brackish fresh-water marsh (Figure O - 12). The soil's sequence in this type of marsh consists of a mat or roots and other parts of marsh vegetation with some mixture of finely divided mucky materials from four to eight inches thick. This is underlain by 1 to 10 feet of coarse to medium-textured fibrous peat. This, in turn, is often underlain by a fairly firm, blue-gray clay and silty clay with thick layers of dark gray clays and silty clays high in organic content. It is estimated that only 10 to 20 per cent of brackish fresh-water deposits consist of inorganic materials.

The strengths of marsh soils are very low. TRECOM reports that cone penetrometer readings taken in various Louisiana marsh areas during spring months, with a standard Corps of Engineers instrument, gave indices of 10 to 40 as the vegetal mat of 2 to 10 inches was pierced and indices of 10 to 20 just below the mat, rising to 30 to 60 at a depth of 6 feet (largely, it is thought, because of friction on the long probe, rather than resistance to penetration of the cone tip.)

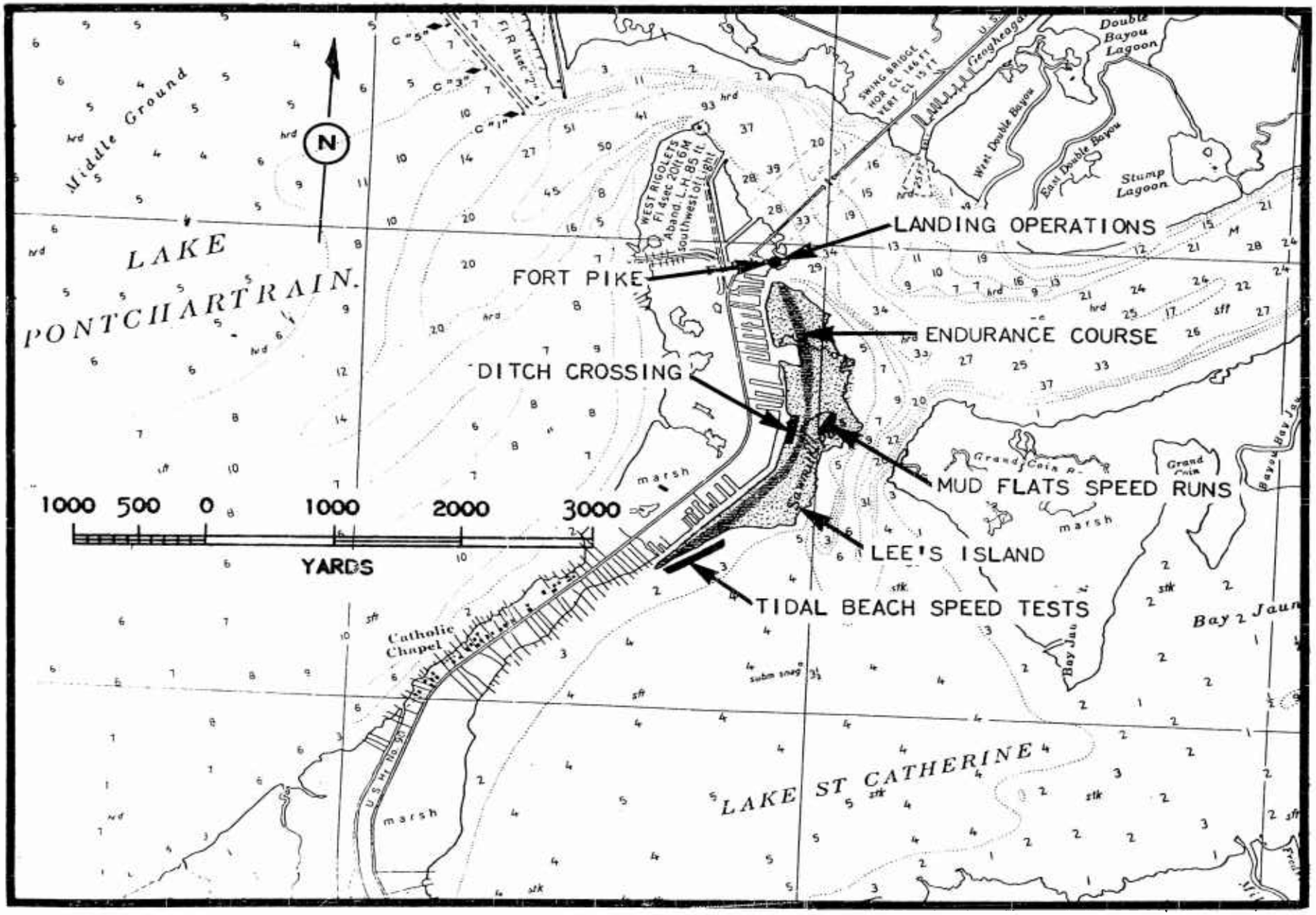


Figure 0-11 Hydrographic Chart of Lee's Island and Fort Pike Test Sites

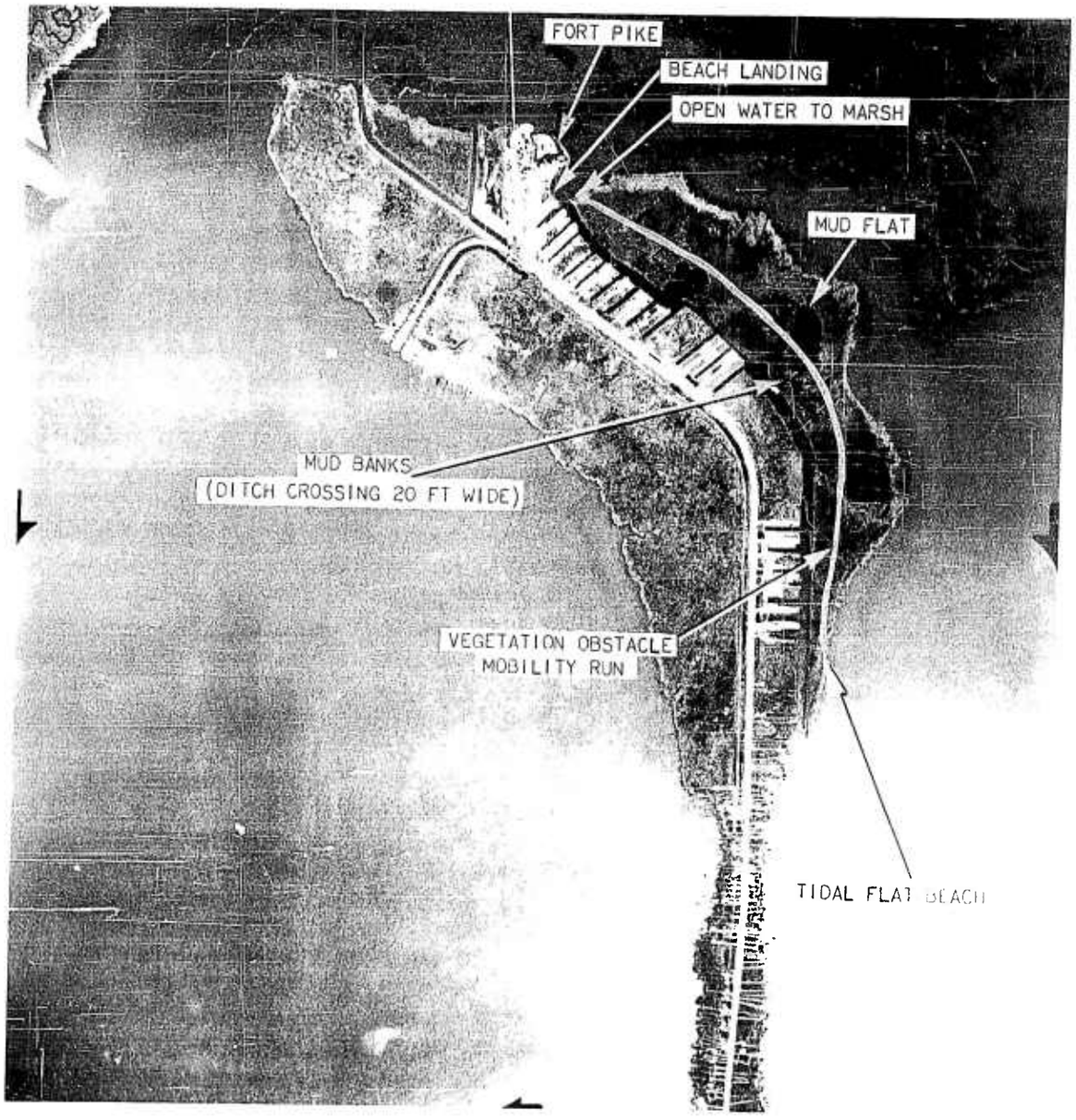


Figure 0-12 Aerial View of Lee's Island and Fort Pike Test Sites

7. FORT PIKE TEST SITE, ORLEANS PARISH, LOUISIANA

This site is located about 21 miles northeast of New Orleans in Orleans Parish, on a marshy peninsula that separates Lake Pontchartrain and Lake St. Catherine. It is situated on the northeast coast, about three quarters of a mile from the northern tip of the peninsula and 200 yards south of U.S. Highway 90 (Figure O - 11).

Soil boxing data indicate that the surface layer at Fort Pike consists of very soft fat clay of recent origin, approximately 10 to 20 feet thick. Available shear test data for this clay have assigned a value of 23 degrees for the angle of internal friction and zero for cohesion. Although the water content of fat clays ranges from 30 to 90 percent dry weight, they are normally consolidated and show an almost straight-line increase of strength with depth, from zero strength at the mudline to about 1,200 pounds per square foot at a depth of 200 feet.

The more important vegetation types found in the vicinity of Fort Pike are reed cane or roseau (Phragmites communis), lance leaf cattail (Typha angustifolia), broad leaf cattail (Typha latifolia), three square (Sciysus olneyi), and leafy three square (Sciysus robustus). Less important varieties include couch or wire grass (Spartina patens), oyster grass (Spartina alterniflora), bayonet rush (Sciysus americana), and big cord grass (Spartina cynosuroides). See Figure O - 12.

8. AUBURN HEIGHTS TEST SITE, OAKLAND COUNTY, MICHIGAN

This test site is located within the city limits of Pontiac, the county seat of Oakland County, Michigan. The land is privately owned but undeveloped. It is situated on the east edge of town, about a half mile north-northwest of the intersection of State Highways 24 and 59 (Figure O - 13).

The terrain is characterized by rolling to extremely rough topography with lakes, swamps, and marshes found in basin-like depressions. The local relief in the immediate vicinity of the test site ranges from a minimum elevation of 868 feet above sea level to a maximum of 950 feet (Figure O - 14). Hillsides are covered with soils varying from loose coarse sands and gravels to sandy silts and clays. A poorly drained clay, containing large amounts of organic material, occupies the depressions. Under normal conditions, this soil is soft and plasric but will become hard when dry. Small quantities of stones are found on the surface and in the soil.

A high water table combined with poor surface runoff and internal drainage produced the marshy area on which the Marsh Screw Amphibian was tested. This low-lying surface is usually wet and therefore soft and slippery. Since peat, muck, swamp soils and similar soil types are practically always impassable to all except the lightest amphibious-type vehicles, this site was selected for testing the mobility and performance potential of the Marsh Screw Amphibian in marshy terrain.

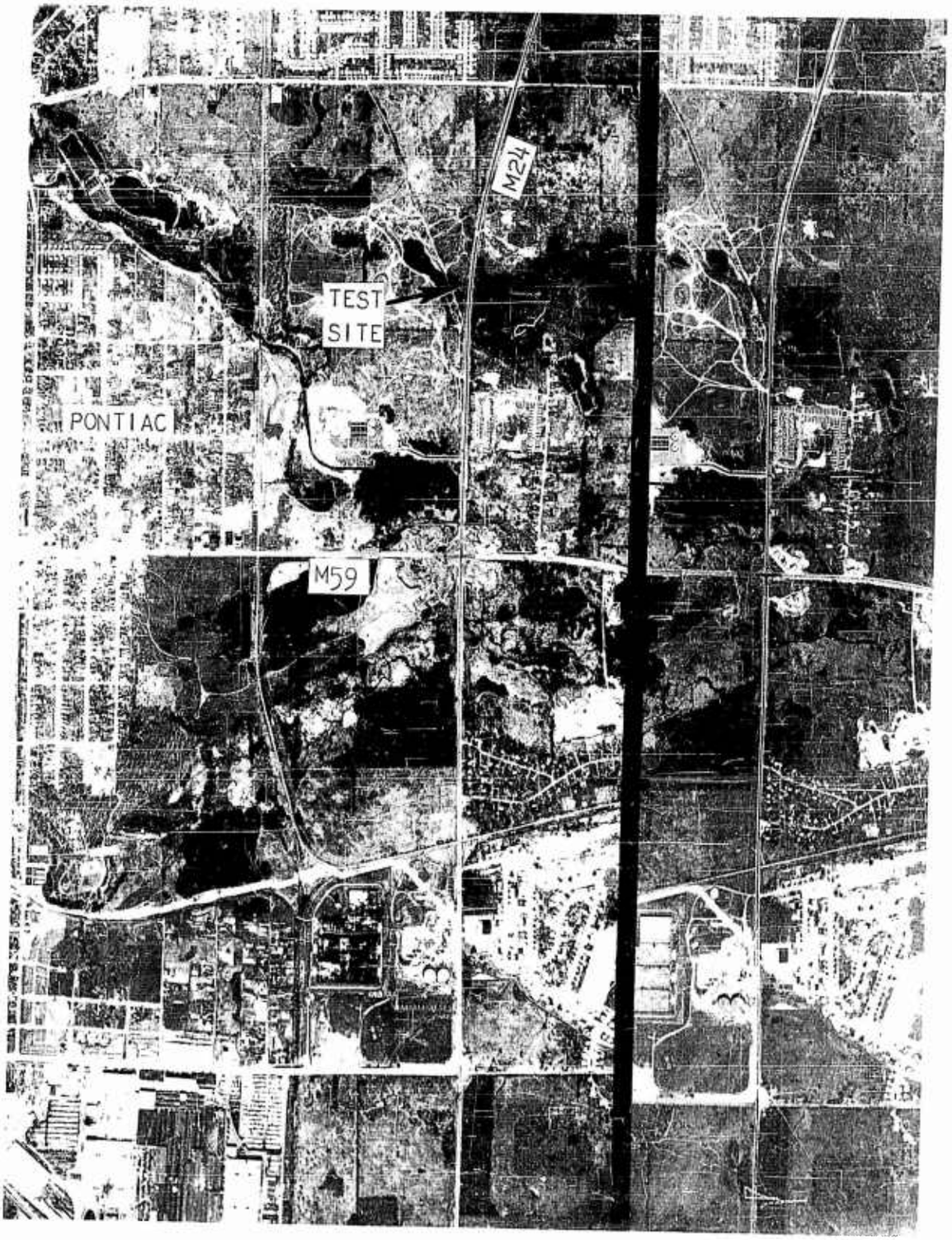


Figure 0-13 Stereogram of Auburn Heights Test Site

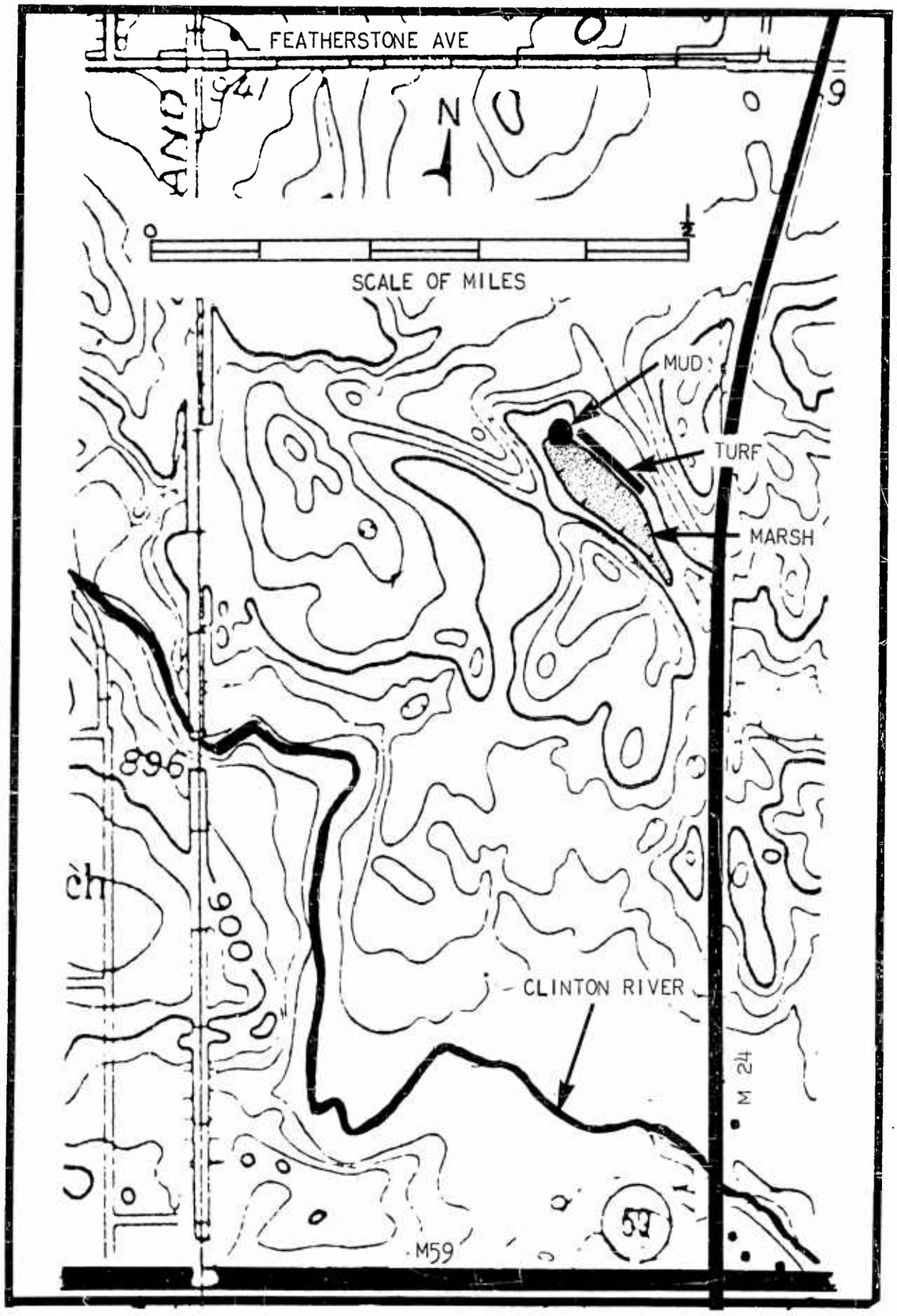


Figure O-14 Topographic Map of Auburn Heights Test Site

9. FIFTEEN MILE TEST SITE, MACOMB COUNTY, MCIHIGAN

This test site is located on Chrysler-owned but undeveloped land in Macomb County, Michigan. Situated seven miles due north of Detroit, the property is bounded by 15 Mile Road on the south, Van Dyke Avenue on the east, 16 Mile Road on the north, and the New York Central Railroad tracks on the west (Figure O - 15).

The topography ranges from nearly level to slightly undulating. A few cobbles and boulders are present on the surface and embedded in the soil. Layers and pockets of silt and sand are also found on the surface. The property contains 220 acres and includes a large L-shaped lake. The elevation in this area averages 615 feet above sea level (Figure O- 16).

Mobility and performance tests of the Marsh Screw Amphibian were conducted in and around the lake. This lake measures 1,400 feet along its north-south axis and 500 feet along its east-west axis. It varies in width from 100 to 200 feet and in depth from five to eight feet. An island, 300 feet long by approximately 50 feet wide, is situated in the smaller section of the lake.

Fine sand and silt comprise the surface soils, underlain by gritty or sandy clay. With normal moisture content, the soil is slightly plastic and easily compacted. It becomes hard when dry and plastic and sticky when wet. The load-bearing capacities and shearing strengths for the four types of soils tested are presented in Figure O - 17 through O - 26.



Figure O-15 Stereogram of Fifteen Mile Test Site

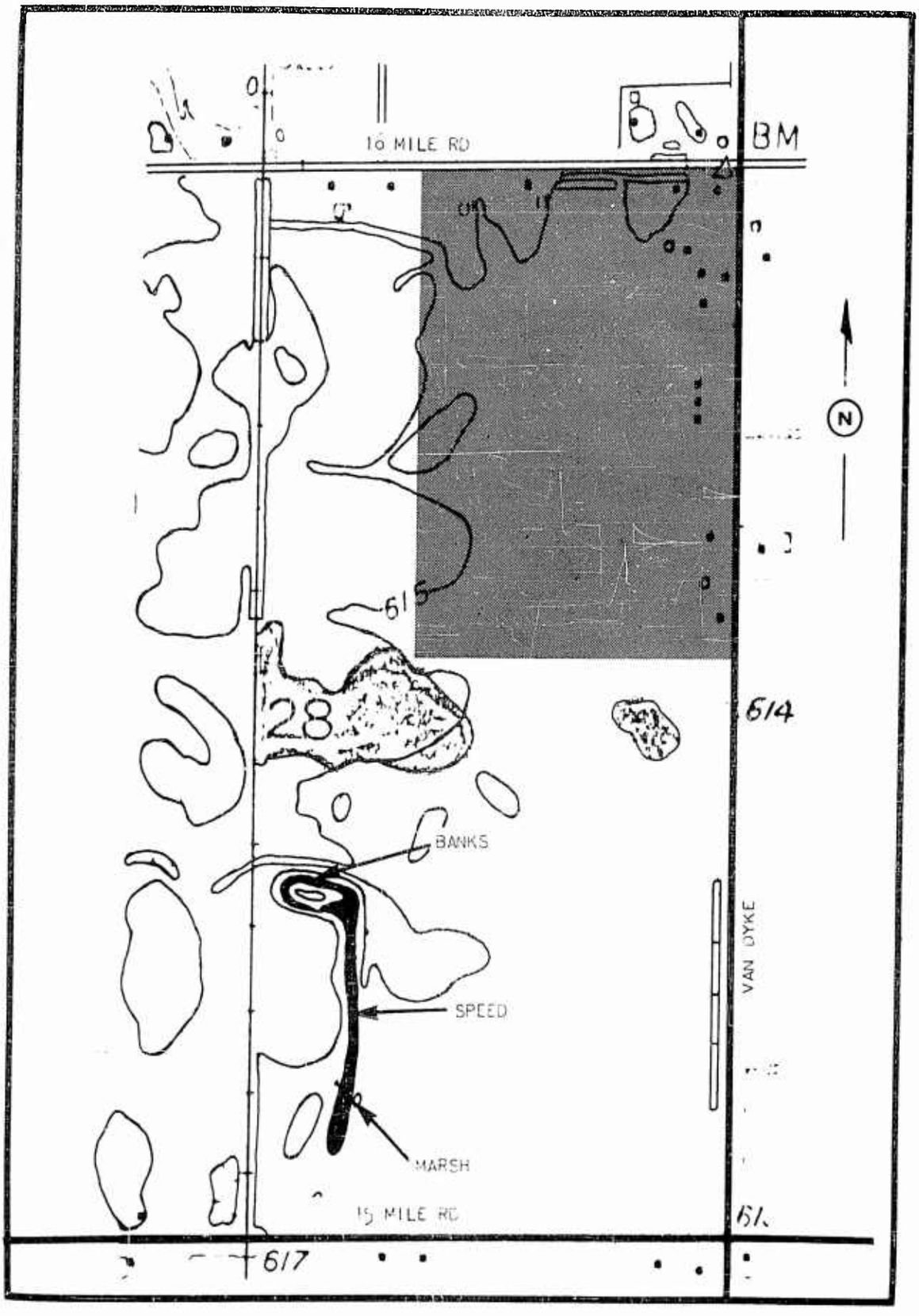


Figure O-16 Topographic Map of Fifteen Mile Test Site

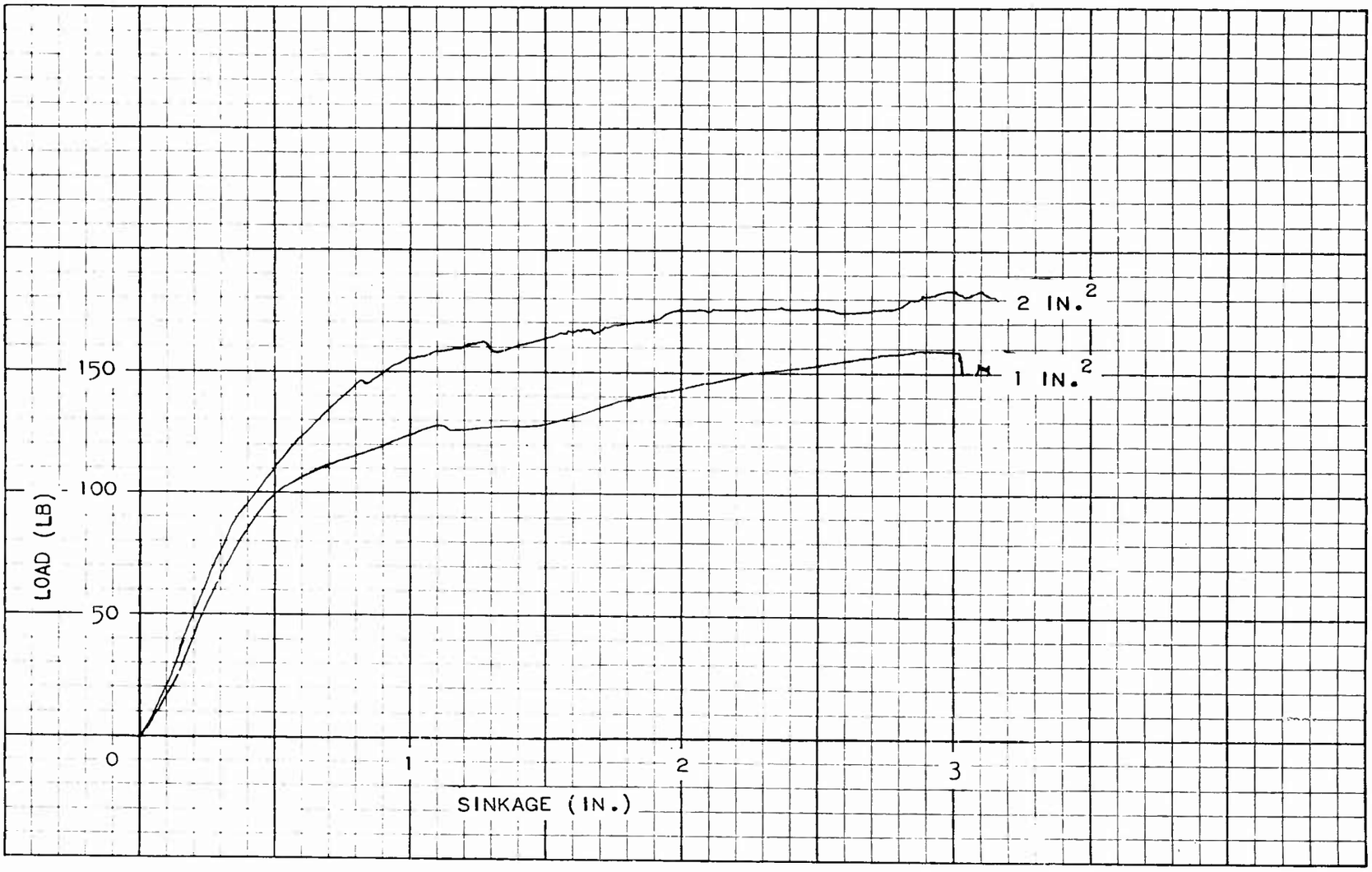


Figure O-17 Soil Bearing Strength - Test Site No. 1 (Turf)

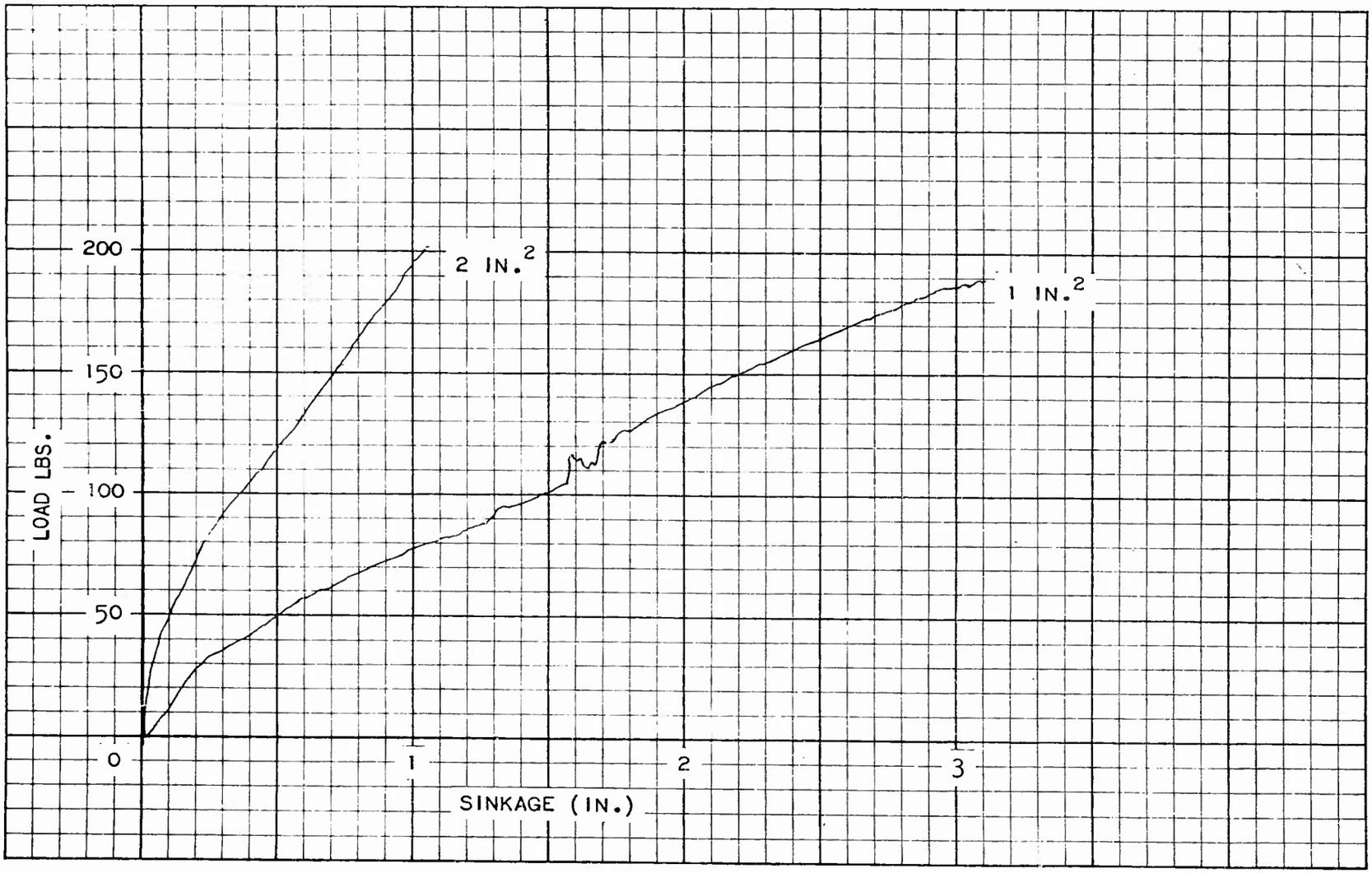


Figure O-18 Soil Bearing Strength - Test Site No. 2 (Fine Sandy Silt)

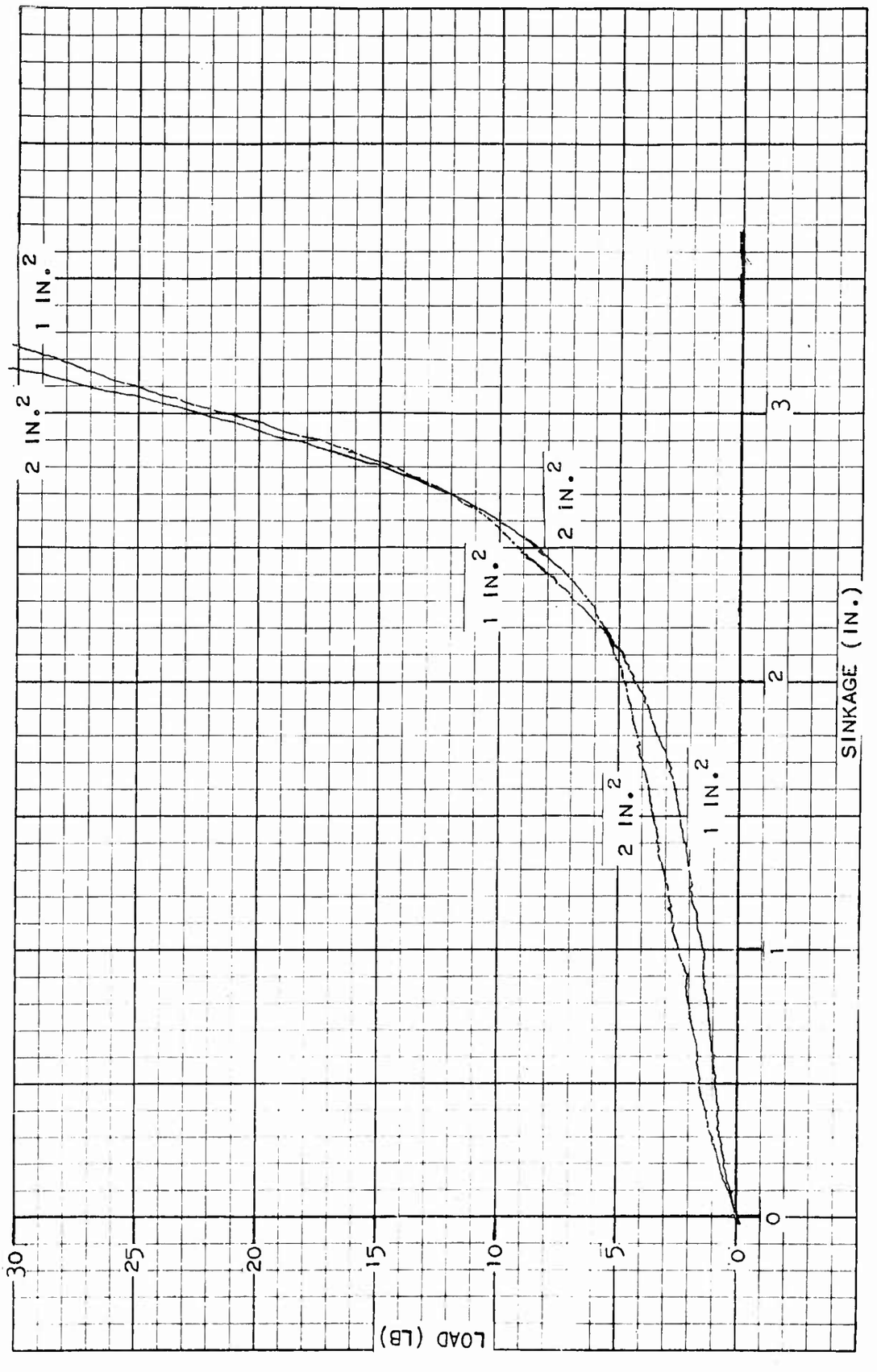


Figure O-19 Soil Bearing Strength - Test Site No. 3 a (Swamp Mud)

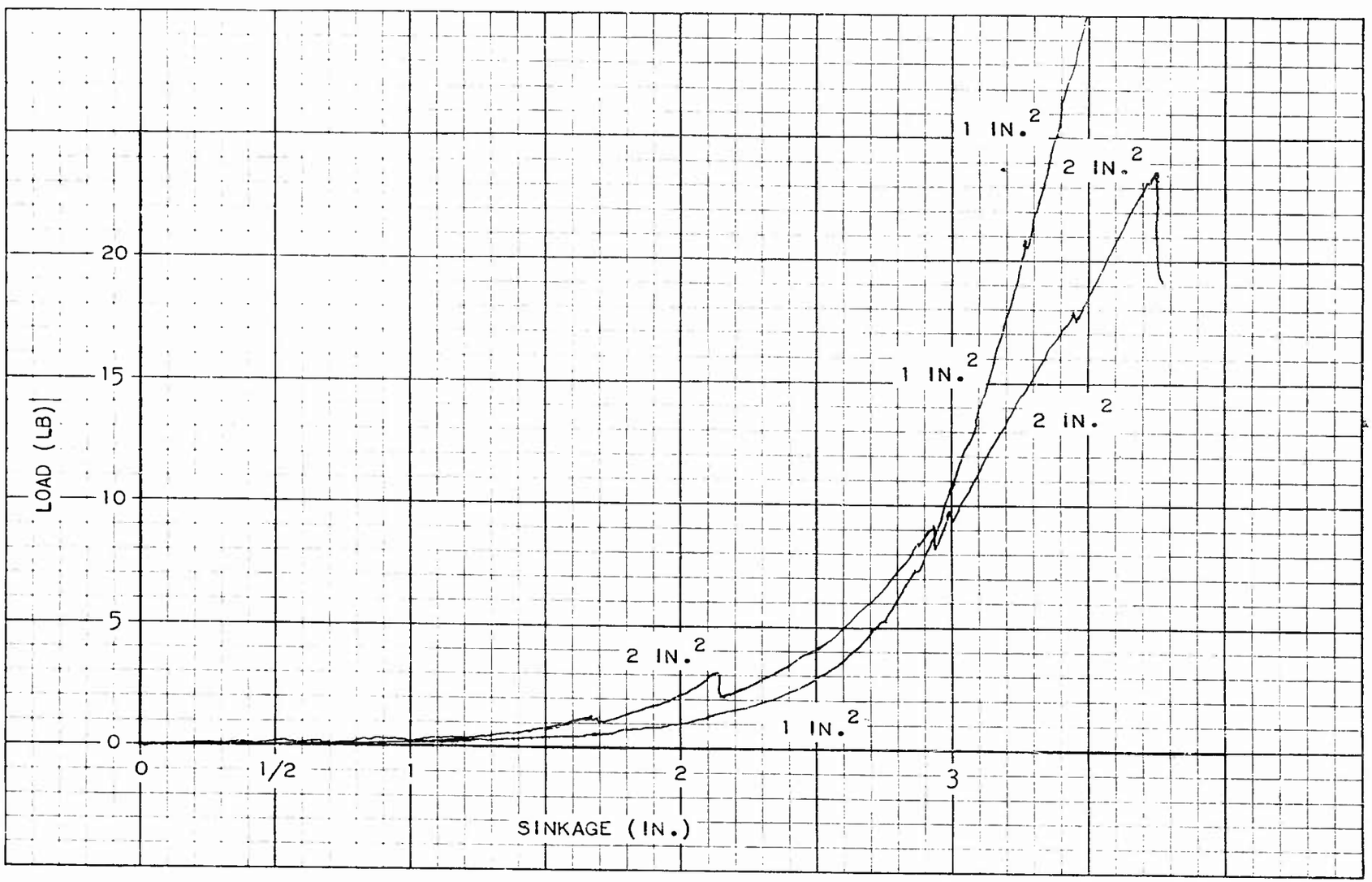


Figure O-20 Soil Bearing Strength - Test Site No. 3 b (Swamp Mud Covered by Water)

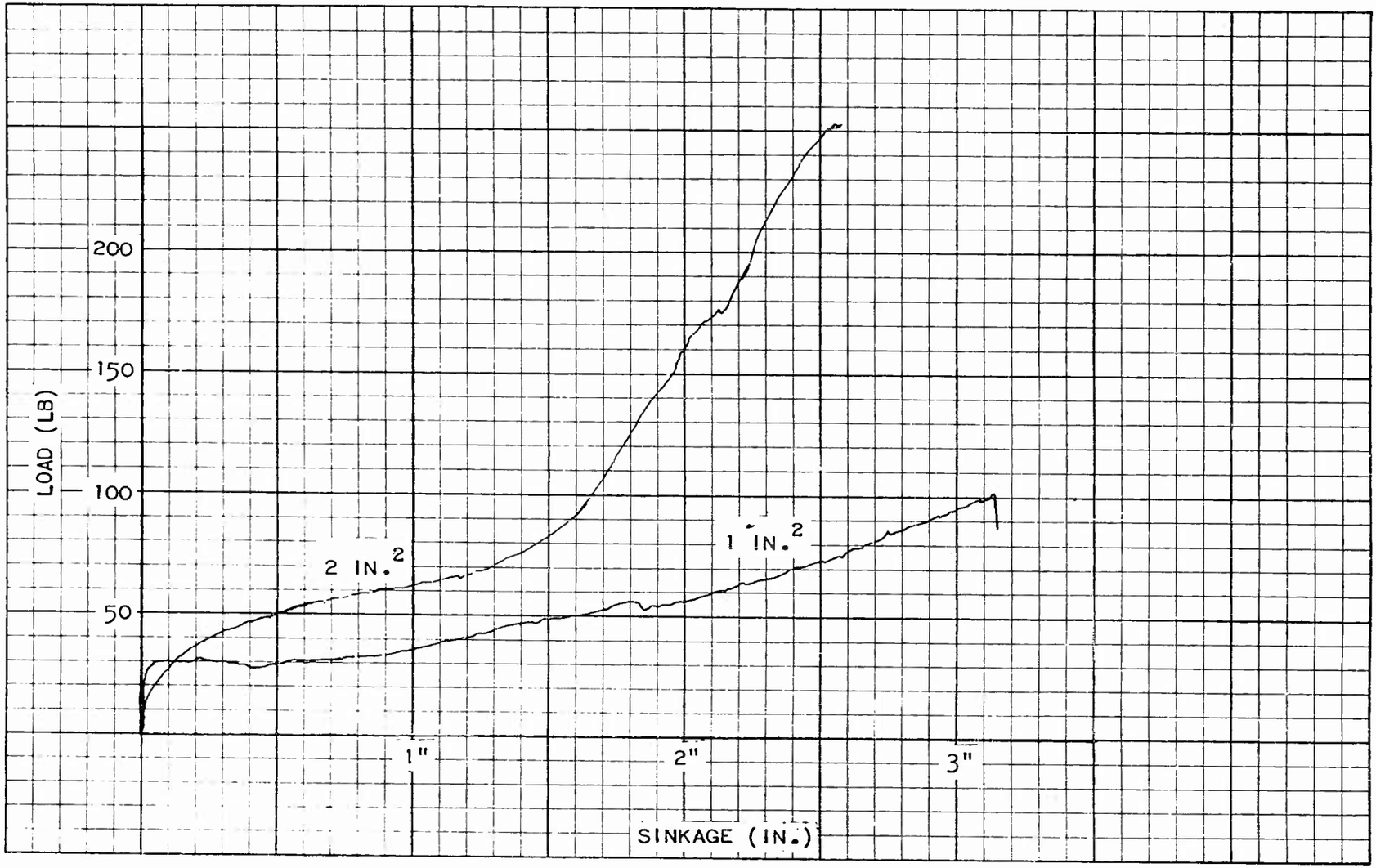


Figure O-21 Soil Bearing Strength - Test Site No. 4 (Muddy Track)

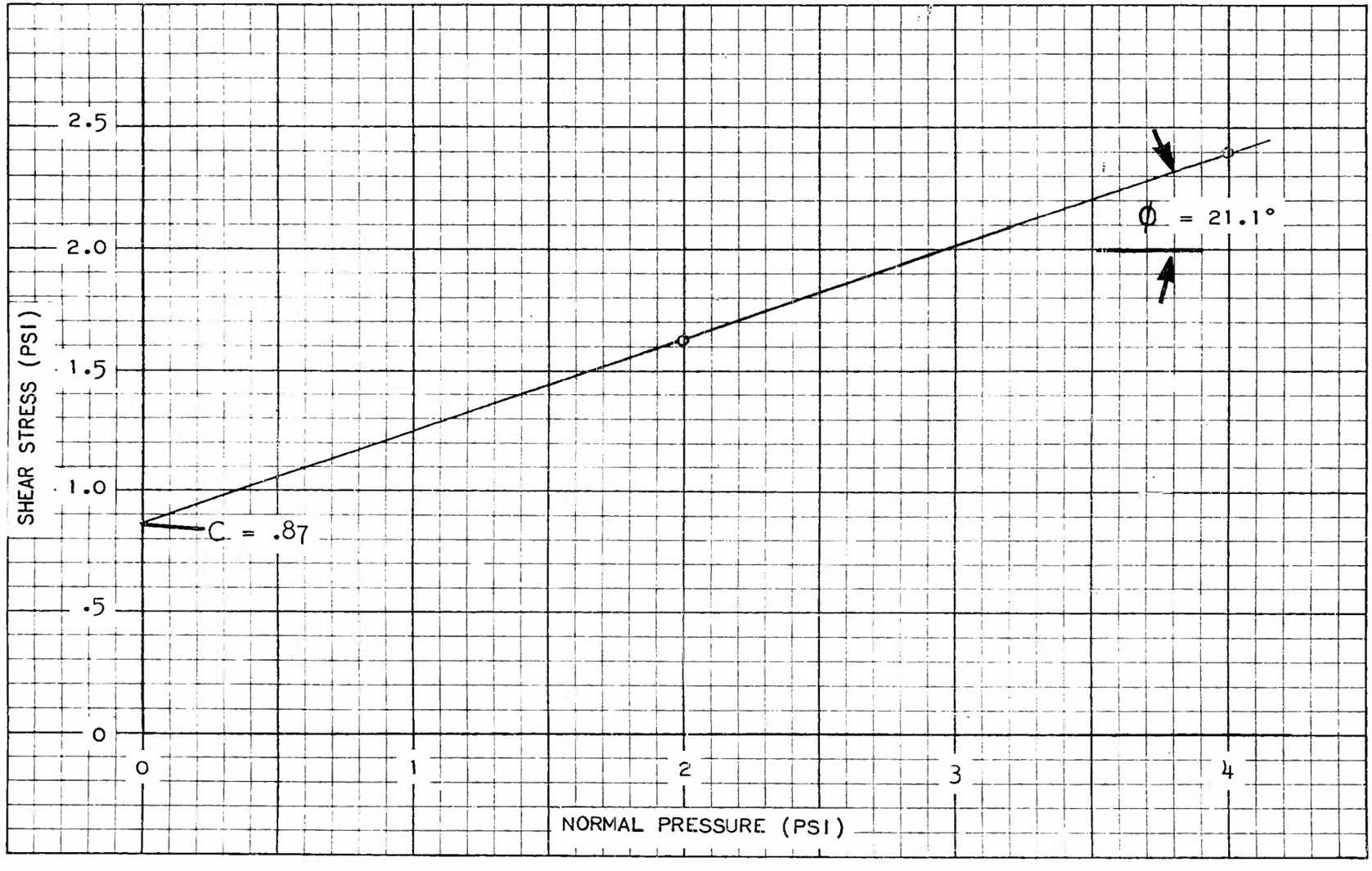


Figure O-22 Soil Shear Strength - Test Site No. 1 (Turf)

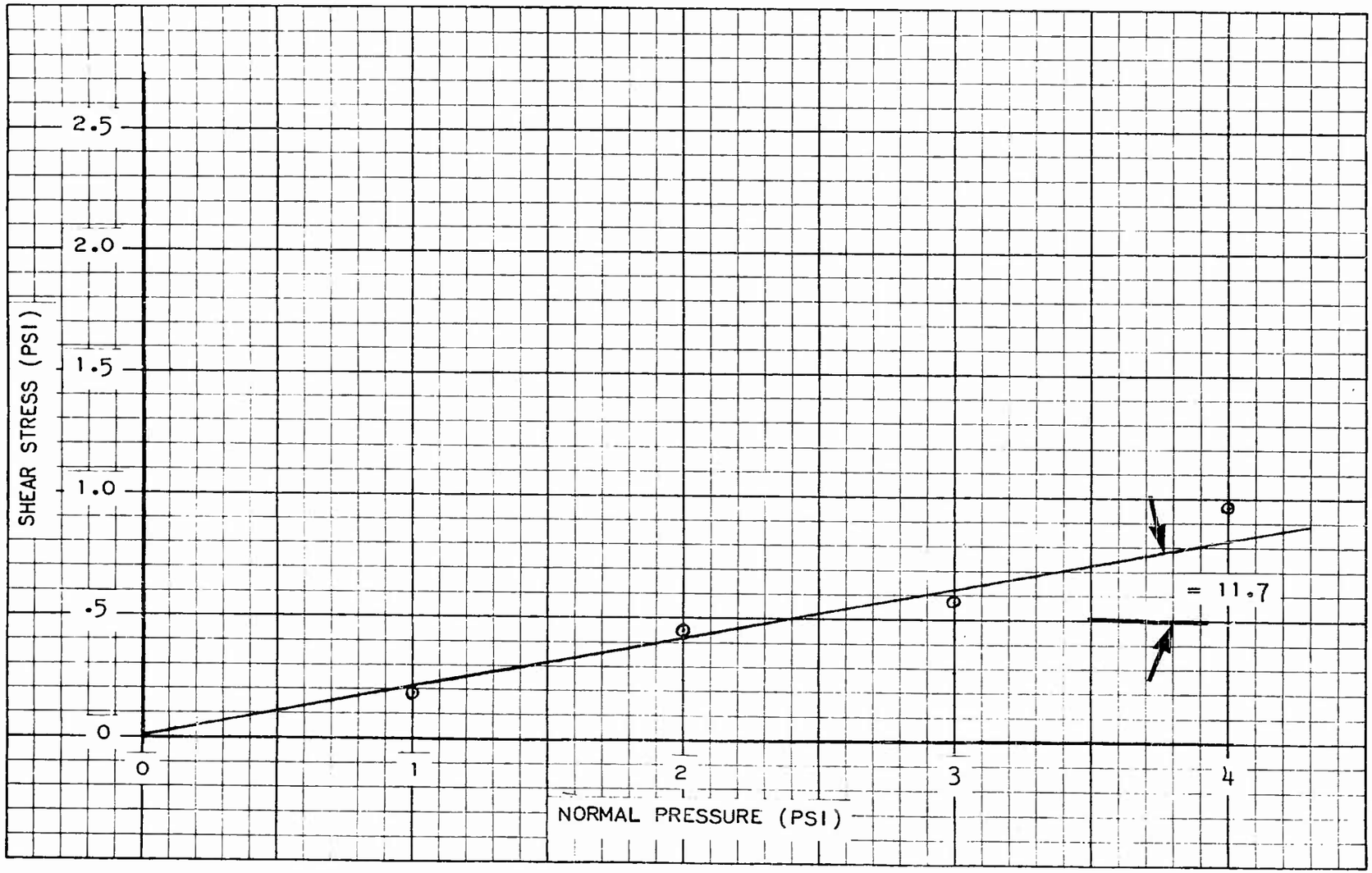


Figure O-23 Soil Shear Strength - Test Site No. 2 (Fine Sandy Silt)

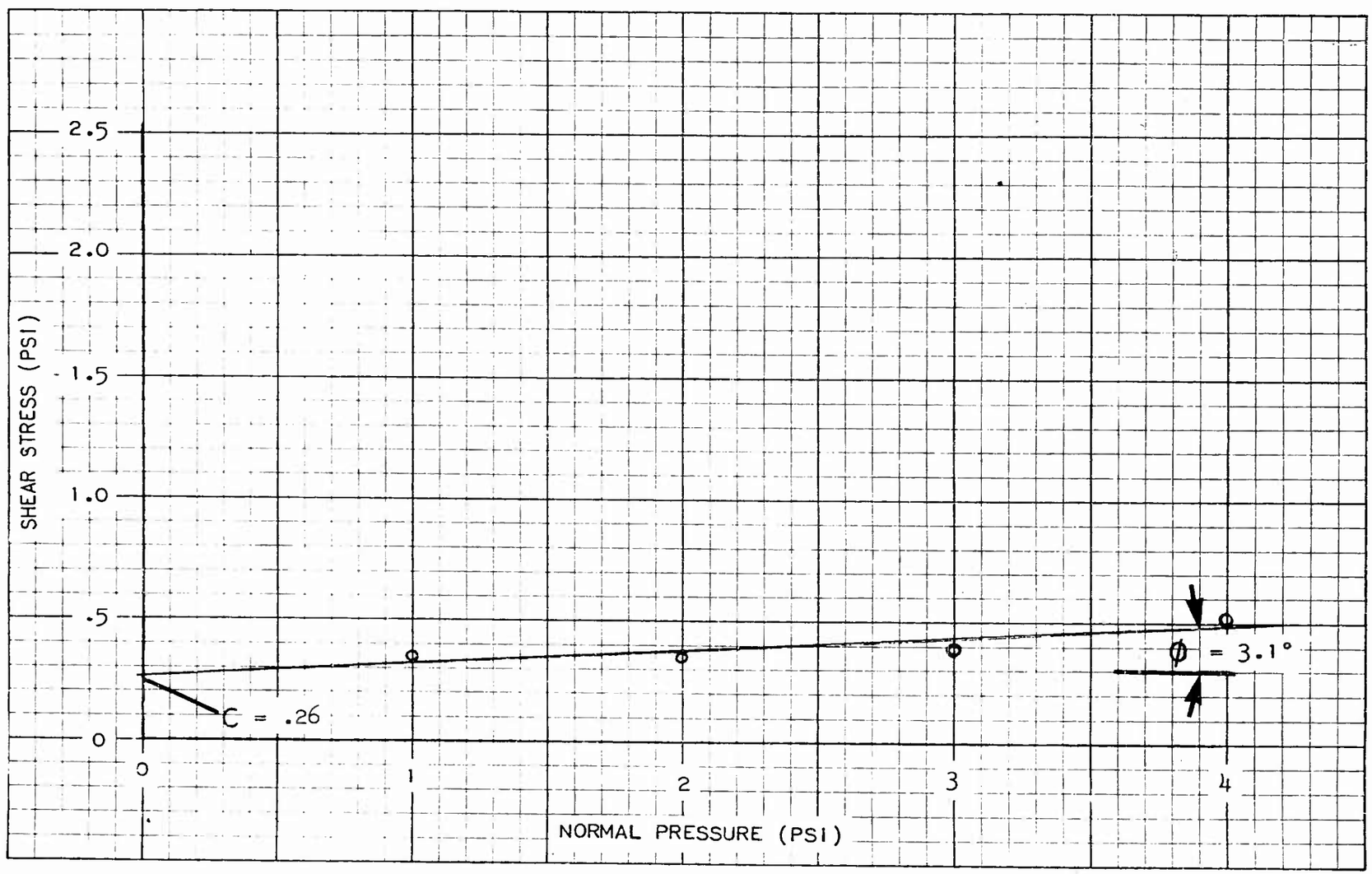


Figure O-24 Soil Shear Strength - Test Site No. 3a (Swamp Mud)

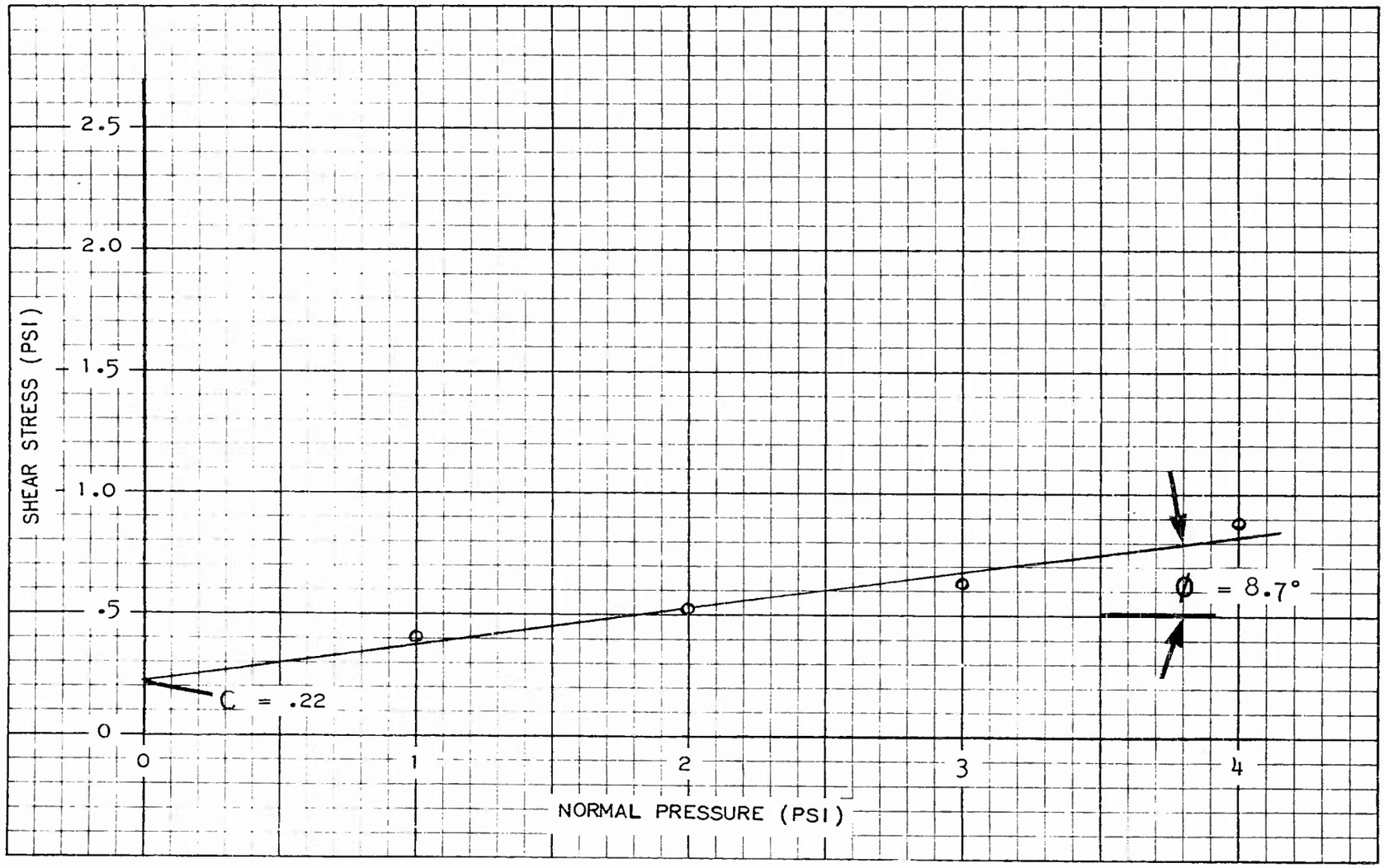


Figure O-25 Soil Shear Strength - Test Site No. 3b (Swamp Mud Covered by Water)

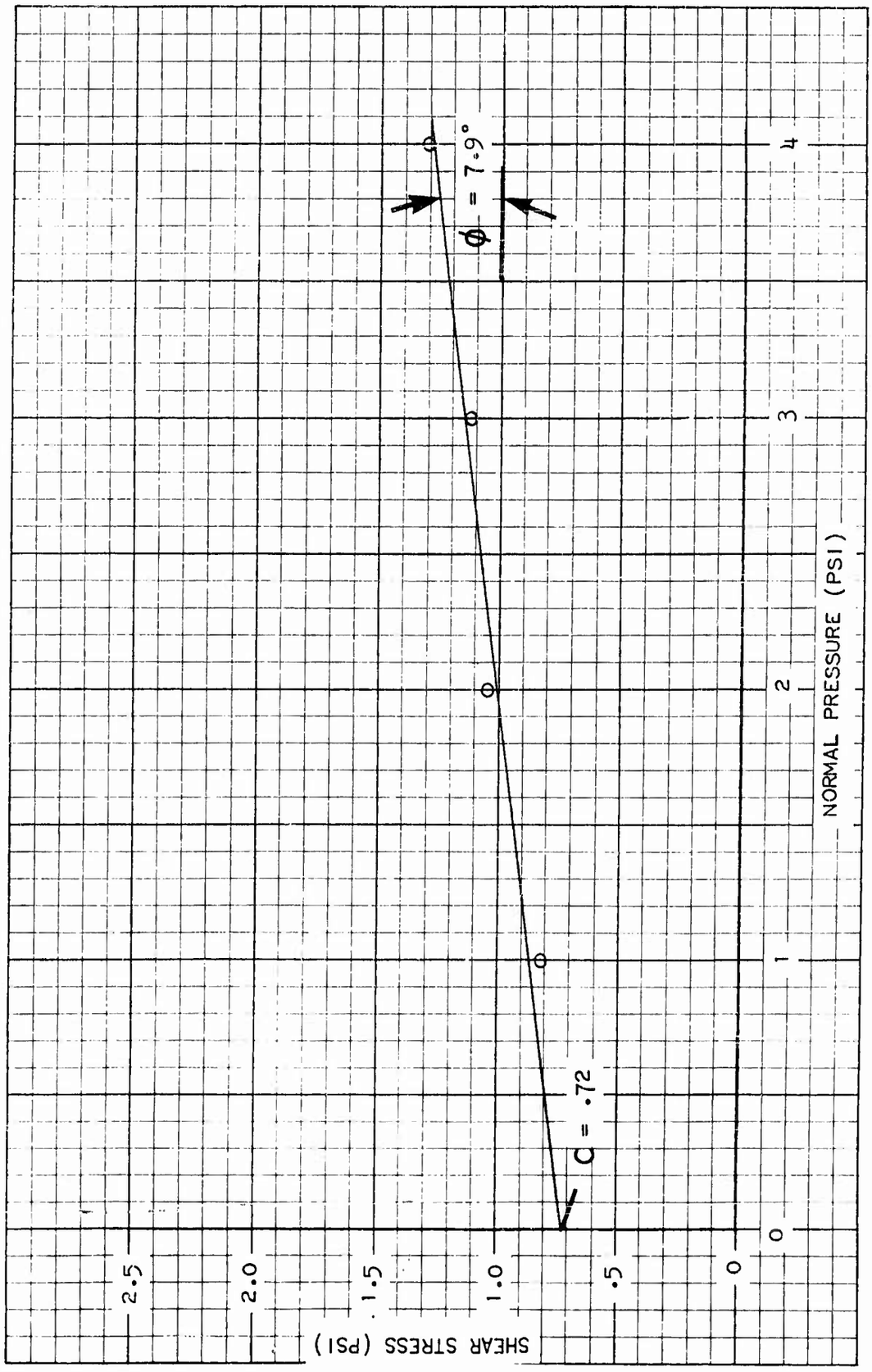


Figure O-26 Soil Shear Strength - Test Site No. 4 (Muddy Track)

APPENDIX P - BUREAU OF SHIPS TEST REPORT

MARSH SCREW AMPHIBIAN

Test Check-Off List

Test	12-26-62 Remarks
a. Dry weight determination by weighing	2335#
b. Operation in the shop with rotors turning in air for one-half hour in each position, to determine satisfactory operation and lubrication.	Accepted 1-10-62
1. 60% forward	Accepted 1-10-62
2. 30% side slope	Accepted 1-10-62
c. Waterborne tests (Payload 1225 lbs and 2/3 fuel)	Three men (525 lbs), sand bags (800 lbs), 5 gallons gasoline (30.5 lbs), fire extinguisher (15 lbs), and tool box (40 lbs). Total 1415 lbs
1. Controls for ahead, reverse and turning.	
2. Operation for three hours at various speeds, including one hour at full power.	Accomplished 2-5-63
Full power speed over measured course.	Accomplished 2-6-63
3. Ability to operate astern.	Satisfactory 2-5-63

4. Freeboard bow and stern when dead in water.	Vehicle was trimmed by loading to requirement of item (c) above.
5. Ability to steer at full power ahead.	Steering at full power is satisfactory. Some drift to starboard is noted. This is correctable.
6. Non-swampability when crashing from full power ahead to maximum	Full power crash satisfactory. However, at full speed astern, vehicle would swamp.
7. Full speed water operation through muddy or swampy area to shore and up on dry land, sand or mud.	Satisfactory. Accomplished 2-8-63
8. Ability to come ashore in the astern direction.	Not possible, due to low silhouette of final drive.
d. Land, mud and sand tests (Payload and fuel, same as for water).	
1. Operation of controls for ahead, reverse and turning.	Accomplished 2-8-63 Controls can be improved. Data attached.
2. Operate in various transmission ranges for two hours, executing turns and in straight away conditions, over earth, swamp and mud, to simulate rice paddy operation, to demonstrate design for speed for this condition.	Accomplished 2-8-63 Data attached.
3. Ability to negotiate on earth bank about 5' high and having approximately 60% slope.	Accomplished 2-7-63 Negotiated a 3' earth bank. Accepted.

MARSH SCREW AMPHIBIAN

Feb. 6, 1963

Measured Course: 264 ft. long - 1/20 mile. - Water Test

Run No. 1 - Driver only - 2nd gear wide open throttle.
Up 19.0 Down 17.3 Up 18.8 Down 18.2 = 9.79 mph
3900 rpm 2nd Gear

Run No. 2 - Driver and one passenger - in driver's seat.
Up 19.2 Down 21.0 Up 19.5 Down 19.5 = 9.06 mph
3800 rpm 2nd Gear

Run No. 3 - 1200 lb Total Payload and 40 gal. gas equivalent.
Up 23.0 Down 24.0 Up 23.9 Down 23.8 = 7.6 mph
3400 rpm 2nd Gear

Feb. 7, 1963

Redistribution of Weights

Run No. 1 - Full Load
Up 24.5 Down 24.1 3000-3400 rpm 7.46 mph

Run No. 2 - 8 Bags up front
Up 23.4 Down 24.5 3300 rpm 2nd Gear 7.32 mph

Feb. 8, 1963

Land Speed Run. Measured Course 264 Ft (1/20 Mile)
Terrain - Wet Muck.

First Gear: 3800 rpm 9.9 mph
Up 19.0 sec Down 24.5 sec

Second Gear: 1850 rpm 7.93 mph
Up 21.8 sec Down 22.7 sec

High Gear: 3700 rpm 4.98 mph
Up 34.5 sec Down 37.8 sec

APPENDIX Q - MOVIE FILM SEQUENCE IDENTIFICATION

All pictures were taken at 16 frames per second.

1. DETROIT RIVER

The first three scenes show the initial operation of the vehicle on the Detroit River. The vehicle was bow heavy and the crew of three the only load.

The next two views, stern and side, show the vehicle at slow speeds to indicate attitude under this condition of loading. Ice floes are present.

The next scene, with a crew of two, shows the increase in bow up attitude for this condition of loading. Considerable maneuvering was required to dodge the ice floes.

2. CHRYSLER PROVING GROUND - CHELSEA, MICHIGAN

The surface consisted of six inches of lightly crusted snow. The first slope shown is 20 percent. It was possible to maneuver on the slopes at fairly respectable speeds. Dry patches of ground and grass slowed down the vehicle considerably.

The next sequence of scenes show the characteristic steering action -- sliding the back end of the vehicle to the left to turn the vehicle to the right.

Note the improvement in driving technique the second time a fast turn is made at the bottom of the hill. This driver had less than one hour of vehicle operation experience

at this time, about 15 minutes of which was in snow.

The final scene shows the method of loading and transporting the vehicle to the various test sites.

4. ALLEGAN COUNTY, MICHIGAN

The vehicle arrived at Allegan County during the coldest time of the 1962-63 winter. Temperatures ranged from 0° to -20° F. An average of 36 inches of loose, drifty snow covered the ground. The vehicle was loaded at times with seven people. Maneuverability was excellent. Previously made ruts did not affect directional control in the soft snow. Speeds of 25 mph were only limited by the engine governor.

5. CHRYSLER MICHOUD FACILITIES

The first series of shots were made during water speed trials. Loading was provided by sandbags. The next sequences covered the water maneuverability portion of the acceptance test program. A BuShips representative is riding in the vehicle during these maneuvers, including sharp turns at full throttle and a crash stop and reverse. It was here noted that the vehicle would ship water if full power reverse was used after a crash stop from forward.

Next is a series of figure "eights", followed by operation with a maximum of weight shift forward. The bow down attitude is pronounced.

Operation on high dry vegetation, close to a canal bank is shown next. Climbing the bank requires a new skill that was not learned as yet. A reverse approach could not be made at this sharp drop off. A rather abrupt, almost vertical entrance into the water was

successfully made. After several tries, the driver developed skill and confidence in the vehicle and negotiated 4 foot, 60 percent slopes.

6. DAUPHIN ISLAND, ALABAMA

The vehicle is much easier to control over ruts, etc., in high coefficient of friction wet sand, when operating in reverse. On loose sand hills the rotors will "dig in" rather than climb a slope over 25 percent grades.

Wet sand near the water's edge caused the most resistance to vehicle travel.

Attempting to turn sharply by locking the inside rotor causes the outer rotor to "dig in".

This first driver was too timid and was replaced.

Surf operation was handled very easily. This was judged to be a 2 foot surf.

Reverse operation over sand hills was limited by the gearbox location.

This driver negotiated the hills that the first driver did not. Ruts on more level portion of the beach did not cause difficulties of vehicle operation.

Rolling the vehicle into a 2 foot surf was tried to determine a degree of vehicle stability. Surfing capabilities are very promising.

Sideways motion on sand is practical for quick maneuvers.

7. LEE'S ISLAND

Tidal mud of varying water content was prevalent on Lee's Island. Directional control was excellent on this mud. Speeds were timed along this tidal beach. A one foot rise at the high water edge is negotiated into dense vegetation, crossing the island, and exiting on the other side. The rotor trails give an indication of rotor slip by a measurement of blade displacement.

Ditch crossing was accomplished up different height banks due to tidal water level changes. These soft banks have a slight overhand left by turf supporting the top edges.

The tidal mud flat was run at 20 mph. A man cannot navigate in this mud without assistance.

8. FORT PIKE

A landing maneuver for hard and stoney beaches was developed to a high degree of efficiency after three tries by an experienced driver. This turf had a base of seashells commonly used for fill and surfacing in this area.

In denser vegetation, landings and travel inland is easily accomplished in the normal forward direction.

9. AUBURN HEIGHTS

A typical Michigan swamp complete with tin cans, beer bottles and tires is used for these tests.

Two drivers, totally unfamiliar with the vehicle up till this time, are shown in a variety of driving maneuvers.

This sod has a hard clay base which makes it very firm and unyielding. A more experienced and heavy footed driver has less trouble negotiating this sod.

Vegetation is not a problem with this vehicle. As vegetation becomes denser, the vehicle is lifted higher out of the water and maximum speeds are increased.

10. CHRYSLER DEFENSE ENGINEERING TEST AREA

Rotor shrouds were installed as a possibility of increasing water speed. No improvement was noted.

The next sequence of scenes shows an unsuccessful attempt to negotiate a 100 percent slope bank. The bank was reduced by an angular approach maneuver, the bank chewed away by the rotors, and then negotiated successfully. Difficulty can be noted here in keeping the vehicle headed straight up the bank. It tends to be pulled sideways when a rotor engages a firm section of the bank. Repeated trials in the same area prepare the bank for a successful crossing.

Under certain conditions of turf, one rotor will spin when the other rotor has the brake applied in attempting sharp turns. Use of reverse will allow these sharp maneuvers to be accomplished.

The final scenes show static thrust and tow resistance tests being made.